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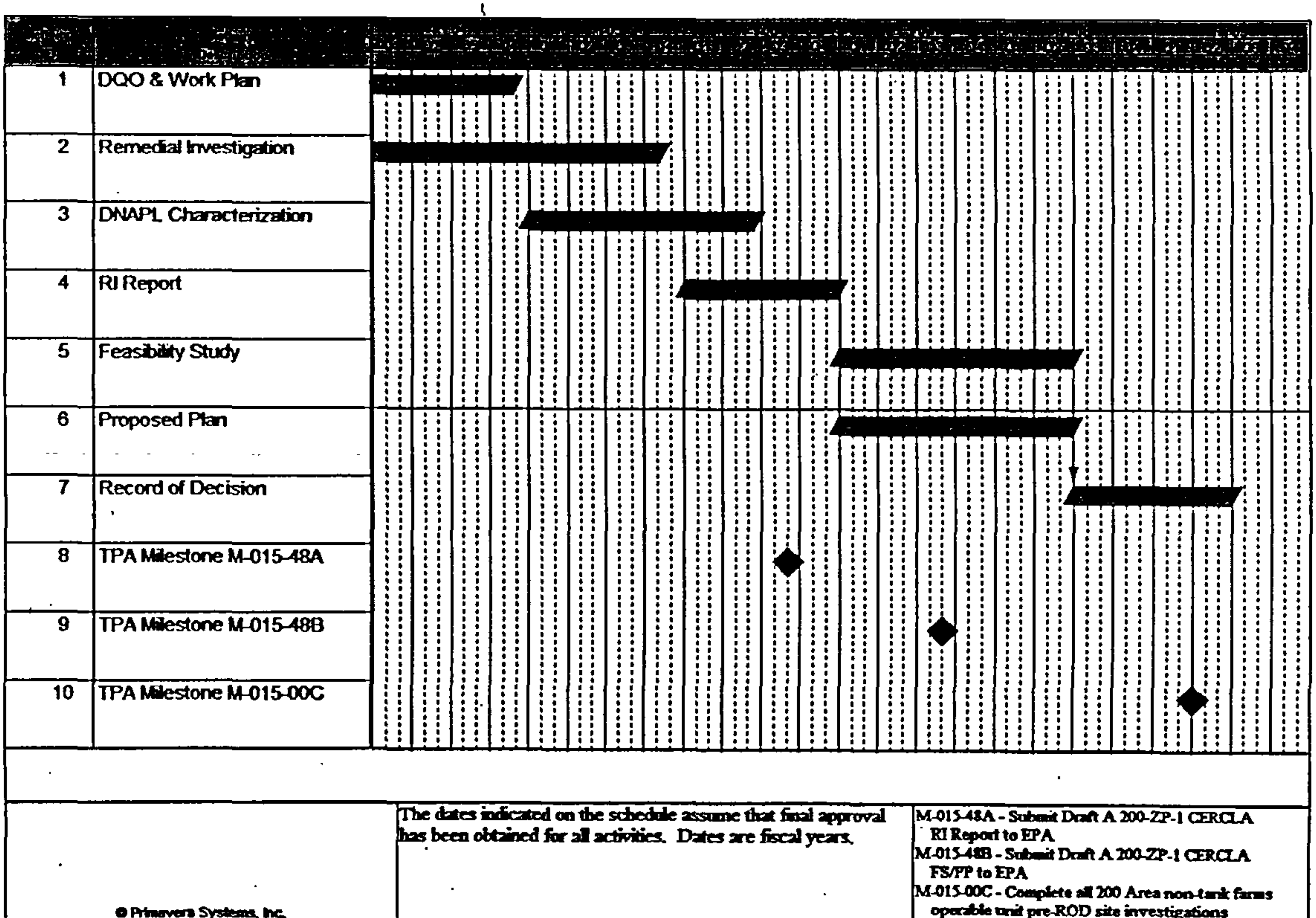
6.0 PROJECT SCHEDULE

Tri-Party Agreement Milestone M-13-00 (Ecology et al. 2003) requires the submission of 200 Area RI/FS work plans by December 31, 2004. Milestone M-15-00 requires completion of the pre-ROD 200 Area RI/FS process for all non-tank farm OUs by December 31, 2008. Tri-Party Agreement Milestone M-16-00 requires the completion of remedial actions for all non-tank farm OUs by September 30, 2024.

The project schedule for activities discussed in this work plan is provided in Figure 6-1 and is consistent with Tri-Party Agreement milestones. Due to the complexity of completing the DNAPL characterization (see Section 5.1.8) within the 200-ZP-1 OU, 4 years is required to complete this CERCLA RI/FS process as opposed to the typical 3-year period that is commonly used for other Hanford RI/FS processes. This schedule will serve as the baseline for the work planning process and will be used to measure the progress of implementation of this process. The schedule for the RI activities and the preparation, review, and issuance of the RI report, the FS, and the proposed plan are also shown in Figure 6-1. The schedule concludes with the preparation of a ROD.

Figure 6-1. Project Schedule for Activities.



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This implements a page change out in document DOE/RL-2003-55, Rev. 0, "Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit." This replaces pages 6-1, Project Schedule and 6-2, Figure 6-1 Project Schedule. Please replace the attached updated page in your current copy.

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H. Author/Requestor
M. E. Byrnes Mark E. Byrnes 7/29/04
(Print and Sign)

Responsible Manager
J. V. Borghese JVBorghese
(Print and Sign)

I. Reviewers

	Yes	Print	Signature	Public Y/N (If N, complete J)
General Counsel	[x]	E.V. Hiskes	[signature]	(Y) / N
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20

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Sheet 1 of 2

DOCUMENT TITLE:	OWNING ORGANIZATION/FACILITY:
Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit	Groundwater Remediation Project

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DOCUMENT TYPE *(Check Applicable)*

☐ Policy ☐ Requirements Document ☐ Procedure ☐ Management Plan
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	Name	Phone Number
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Name *(print)*	Organization
J. V. Borghese	Manager, GW Remedial Actions
J. D. Isaacs	Project Engineering Manager
J. A. Winterhalder	Environmental Compliance
M. E. Byrnes	GW Remeidal Actions

APPROVAL SIGNATURES

	Date Signed
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Revision 0

Remedial Investigation/Feasibility Study Work Plan for the 200-ZP-1 Groundwater Operable Unit

M. E. Byrnes
Fluor Hanford, Inc.

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Assistant Secretary for Environmental Management

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

J. Aardal 8-17-2004
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EXECUTIVE SUMMARY

This work plan is intended to direct data collection that will allow completion of the remedial investigation/feasibility study (RI/FS) and will support selection of a final remedial action for all site contaminants at the Hanford Site's 200-ZP-1 Operable Unit (OU). The data quality objective (DQO) document on which this work plan is based, *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process* (FH 2003b), was completed in June 2003 with concurrence from the U.S. Department of Energy and U.S. Environmental Protection Agency.

This work plan is in support of *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 2003) Milestone M-15-00C. The Tri-Party Agreement provides for the integration of remedial actions under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* with corrective actions for treatment, storage, and disposal (TSD) units under the *Resource Conservation and Recovery Act of 1976*. The TSD units that contribute to groundwater contamination at the 200-ZP-1 OU include the T Tank Farms, TX-TY Tank Farms, Low-Level Waste Management Areas 3 and 4, and the State-Approved Land Disposal Site.

The overall strategy for the work plan is briefly summarized as follows:

- A list of contaminants of potential concern (COPCs) was prepared based on historical information contained in the referenced literature and existing groundwater analysis data.
- A COPC was generally excluded from further consideration if it was not carcinogenic or toxic; if it was not mobile in soil; if it had a half life of less than 2 years; if it had not been used in site processes; if it was mobile and had not been detected in groundwater above background; or if the risk information obtained was nonspecific, as is the case with total organic carbon. Remaining contaminants were deemed to be contaminants of concern (COCs).

- Preliminary target action levels outside the core zone were determined for COCs based on the more stringent standard of maximum contaminant level values or *Washington Administrative Code* 173-340-720(4) values. These values were modified as appropriate if the background levels or detection limits were above the regulatory limits. For some contaminants, regulatory limits were unavailable and other applicable or relevant and appropriate requirements may be used to determine appropriate target action levels.
- Historical groundwater data collected from wells in the 200-ZP-1 OU were compared to the target action levels. If a well historically had a particular analyte found above the target level, the well will be monitored for that analyte. Eight analytes (1,2-dichloroethane, benzene, methylene chloride, tetrachloroethylene, antimony, iron, fluoride, and manganese) have been added to several wells as a result of these comparisons.
- It was determined that to assist decision making during the remedial investigation process, points of calculation would be established inside and outside of the core zone. Inside the core zone, the preliminary target action levels for a specific plume and COC would be a level predicted by modeling so the preliminary target action levels would not be exceeded. The points of calculation that will be used when performing risk assessments will include points that represent the Columbia River, Central Plateau boundary, four corners of the operable unit boundary, and the center of the largest groundwater contamination plume (carbon tetrachloride), as well as the center of any other contaminant plumes that are outside the overlay of the carbon tetrachloride plume (5 µg/L isopleths).
- Eight new monitoring wells will be drilled in the 200-ZP-1 OU. The wells (depending on the plumes they are expected to define) will be tested for appropriate COCs on a periodic basis that will decrease over time if no COCs are found in the wells.
- Selected existing wells will be sampled and analyzed for an additional expanded suite of COCs in 2004, and again in 2006. If a well is found to contain any of these additional COCs over the target action level, they will be evaluated and a sampling and analysis plan will be prepared to ensure that potential future contaminant plumes are not missed.

If the additional COCs are not detected, they will not be considered further in the RI/FS process.

- Three of the new wells have been selected to undergo more extensive analysis of COCs and modeling input parameters at various depths in the saturated zone to allow determination of the vertical extent of contamination. This provides information for use in computer models to predict plume size, migration rates, and other parameters of concern. The modeling input parameters include, for example, particle size, density, porosity, hydraulic data, pH, temperature, and depth measurements.

The proposed sampling locations were selected with the goals of defining the vertical and horizontal plume boundaries and the locations, types, and amounts of contaminant concentrations. The existing monitoring well network has been used to the maximum extent possible.

The Systems Assessment Capability (SAC) framework (a construct of Hanford-specific Sitewide models) developed by Pacific Northwest National Laboratory will be used as the primary risk assessment framework to support the RI/FS. It is anticipated that the SAC will help predict behavior of contaminants such as movement through various media, concentrations, and locations and the effect on environmental receptors.

A Record of Decision for the 200-ZP-1 OU will be obtained through the RI/FS process using the data collected in accordance with this work plan. It is anticipated that the scope of this project, and to some extent the specific project plans, will be developed iteratively. As new information is acquired or new decisions are made, data requirements are to be re-evaluated and, if appropriate, project plans will be modified.

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TERMS

AAMSR	aggregate area management study report
AEA	*Atomic Energy Act of 1954*
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFEST	Coupled Fluid, Energy, and Soluble Transport (code)
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COPC	contaminant of potential concern
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
DR	decision rule
DS	decision statement
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
ERA	expedited response action
FY	fiscal year
GAC	granular activated carbon
gpm	gallons per minute
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HEIS	Hanford Environmental Information System
IRM	interim remedial measure
ISRM	In Situ Redox Manipulation
ITRD	Innovative Treatment and Remediation Demonstration
K_a	abiotic hydrolysis degradation
K_d	distribution coefficient
LFI	limited field investigation
LLWMA	Low-Level Waste Management Area
MASS2	Modular Aquatic Simulation System 2D (code)
MNA	monitored natural attenuation
ORP	U.S. Department of Energy, Office of River Protection
OU	operable unit
OSWER	Office of Solid Waste and Emergency Response
PCE	tetrachloroethylene
PFP	Plutonium Finishing Plant
PNNL	Pacific Northwest National Laboratory
ppb	parts per billion
ppm	parts per million
PRF	Plutonium Reclamation Facility
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control

RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RECUPLEX	Recovery of Uranium and Plutonium by Extraction
RI/FS	remedial investigation/feasibility study
RFI/CMS	remedial field investigation/corrective measures study
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
SAC	System Assessment Capability
SAP	sampling and analysis plan
SARA	*Superfund Amendments and Reauthorization Act of 1986*
STOMP	Subsurface Transport Over Multiple Phases (code)
TAG	Technical Advisory Group
TCE	trichloroethylene
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TSD	treatment, storage, and disposal
UPR	unplanned release
VADER	Vadose Zone Release (code)
VOC	volatile organic compound
WIDS	Waste Information Data System
WMU	waste management unit

METRIC CONVERSION CHART

Into Metric Units			Out of Metric Units		
If You Know	*Multiply By*	*To Get*	*If You Know*	*Multiply By*	*To Get*
Length			**Length**		
inches	25.4	millimeters	millimeters	0.039	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles	1.609	kilometers	kilometers	0.621	miles
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.093	sq. meters	sq. meters	10.76	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.6	sq. kilometers	sq. kilometers	0.4	sq. miles
acres	0.405	hectares	hectares	2.47	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.035	ounces
pounds	0.454	kilograms	kilograms	2.205	pounds
ton	0.907	metric ton	metric ton	1.102	ton
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.033	fluid ounces
tablespoons	15	milliliters	liters	2.1	pints
fluid ounces	30	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.47	liters	cubic meters	35.315	cubic feet
quarts	0.95	liters	cubic meters	1.308	cubic yards
gallons	3.8	liters			
cubic feet	0.028	cubic meters			
cubic yards	0.765	cubic meters			
Temperature			**Temperature**		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius	Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity			**Radioactivity**		
picocuries	37	millibecquerel	millibecquerels	0.027	picocuries

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1.0 INTRODUCTION

This work plan describes the operable unit (OU) setting and establishes the objectives, tasks, and schedule for conducting the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) for the 200-ZP-1 Groundwater OU. As agreed upon by the U.S. Department of Energy (DOE), Richland Operations Office (RL) and the U.S. Environmental Protection Agency (EPA), this work plan supports the final remedy selection for the 200-ZP-1 OU.

This work plan and associated sampling and analysis plan (SAP) (presented as Appendix A of this work plan) consolidate the ongoing monitoring with the RI/FS characterization and supersede DOE/RL-2002-17, *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE-RL 2002).

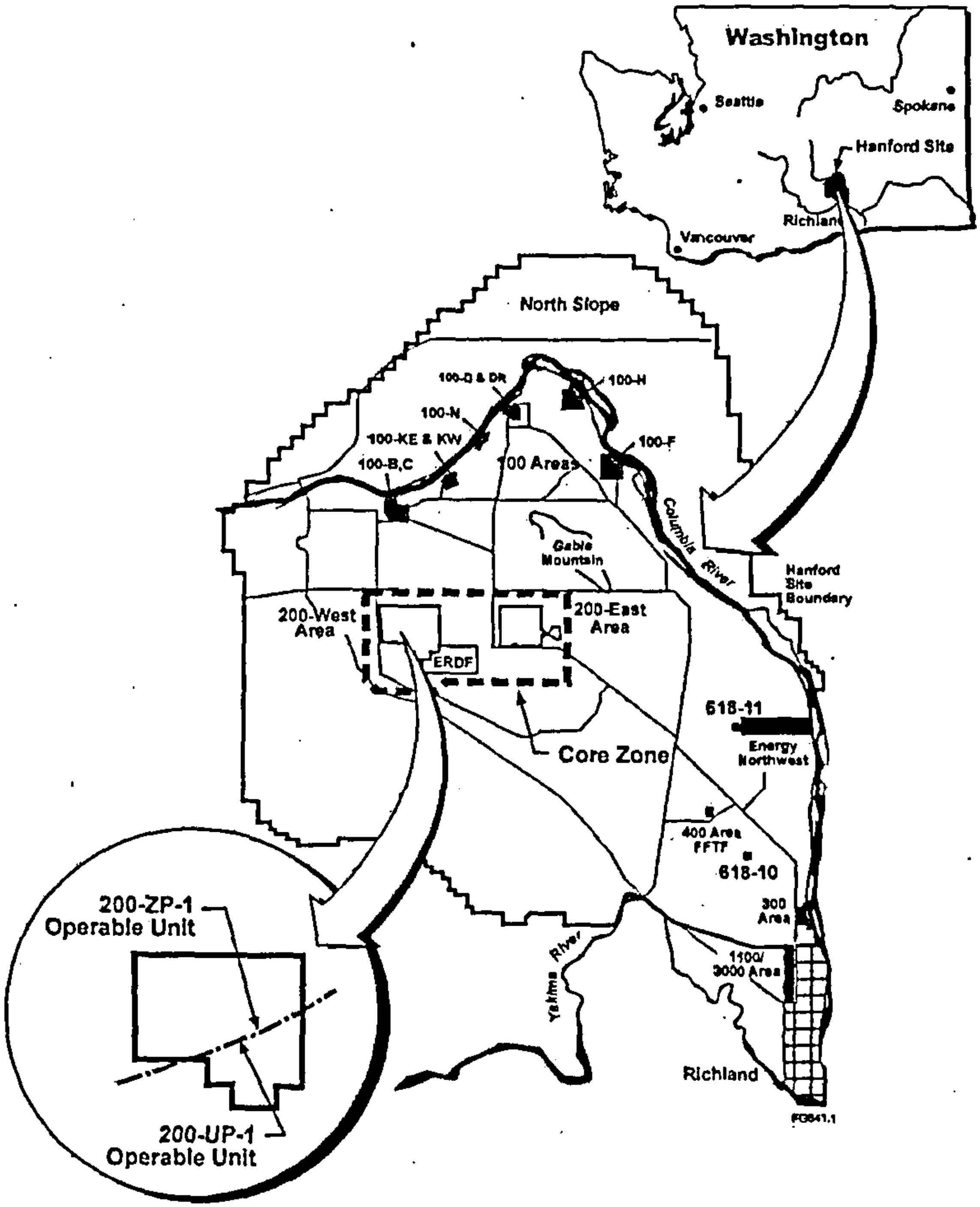
Figure 1-1 shows the location of the 200 West Area at the Hanford Site. Appendix B provides a plate map that shows the 200-ZP-1 OU and its relationship to the 200-UP-1 OU. The 200-ZP-1 Groundwater OU is one of two groundwater OUs located in the 200 West groundwater aggregate area of the Hanford Site. The 200-ZP-1 Groundwater OU underlies the T Plant and Z Plant aggregate areas. This OU contains Z Plant, T Plant, Low-Level Waste Management Areas (LLWMAs) 3 and 4, T Tank Farm, TX-TY Tank Farm, and liquid effluent disposal sites.This work plan does not address the vadose zone concerns within the 200-ZP-1 OU. However, data and information from studies of the vadose zone will provide input to modeling and risk assessment activities conducted based on data generated as a result of this work plan.

The potential contribution of contamination flux from CERCLA waste sites in the vadose zone to the groundwater is currently being addressed by the Waste Site Remediation Project. The project is scheduled to complete waste site remediation activities in the vicinity of Z Plant by 2017.

Although this work plan does not address compliance issues related to the *Resource Conservation and Recovery Act of 1976* (RCRA) treatment, storage, and disposal (TSD) units within the OU, some TSD units have impacted groundwater in the 200-ZP-1 OU. The groundwater OU will be remediated under CERCLA; therefore, the history and the potential contaminant of concern (COC) contribution of the TSD units to groundwater in the 200-ZP-1 OU are appropriate to consider in this work plan. The Waste Site Remediation Project and the Tank Farms Project both address the potential contribution of contamination from RCRA sites to groundwater in the 200-ZP-1 OU. These sites will be evaluated for impact to groundwater in the 200-ZP-1 OU when the data are available. Information for these sites is anticipated to be available according to the following schedule:

- TSD unit T: 2010 closure date.
- TSD unit TX-TY: 2010 closure date.
- LLWMA 3: Units are active and no individual closure dates are established. However, in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) Milestone M-016-00 (Ecology et al. 2003), all 200 Area non-tank farm OUs must be closed by 2024.

Figure 1-1. Location of 200 West Area Containing the 200-ZP-1 Groundwater Operable Unit.



- LLWMA 4: Units are active and no individual closure date has been established. However, in accordance with Tri-Party Agreement Milestone M-016-00 (Ecology et al. 2003), all 200 Area non-tank farm OUs must be closed by 2024.
- State-Approved Land Disposal Site: Although this TSD unit is located outside of the 200 West Area boundary, a tritium plume from the facility is monitored and may impact other plumes in the 200-ZP-1 Groundwater OU in the future. The TSD unit is active and no individual closure date is established. However, under Tri-Party Agreement Milestone M-016-00 (Ecology et al. 2003), all 200 Area non-tank farm OUs must be closed by 2024.

The Waste Disposal/Groundwater Remediation Projects will evaluate and make use of estimated model input parameters used by other waste site and Sitewide assessment projects (e.g., Truex et al. 2001, Bryce et al. 2002) to estimate mass flux of contaminants from the vadose zone and contaminant transport in the aquifer for use in risk assessments undertaken for this RI/FS.

The presence or absence of dense nonaqueous phase liquids (DNAPLs) in the 200-ZP-1 OU and its three-dimensional distribution within the OU is recognized as a data gap that needs to be filled to support the CERCLA RI/FS process. The DNAPL investigations in the vadose zone and groundwater in the vicinity of the 216-Z-9 Trench are currently being addressed by *Sampling and Analysis Plan for Investigation of Dense Nonaqueous Phase Liquid Carbon Tetrachloride at the 216-Z-9 Trench* (DOE-RL 2003c). A separate SAP will be prepared to address the remainder of the DNAPL characterization strategy identified in Section 6.5 of *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (DOE-RL 2004). This DNAPL characterization data shall be available to support the CERCLA RI/FS project schedule identified in Figure 6-1 of this work plan. RL is committed to complete DNAPL investigations in the timeframe specified in the project schedule (Figure 6-1) and DOE-RL (2004).

Activities conducted under this work plan will conform to the conditions set forth in the Tri-Party Agreement (Ecology et al. 2003) and amendments signed by the Washington State Department of Ecology (Ecology), EPA, and RL. This work plan is in support of Tri-Party Agreement Milestone M-015-00C, which requires the completion of all 200 Area non-tank farm OU pre-Record of Decision (ROD) documents by December 31, 2008.

Much of the background information, physical setting, COCs, and conceptual models are discussed in other project documents and will not be addressed in extensive detail in this work plan. The background section of this work plan (Section 2.0) discusses these documents briefly and summarizes the available information. The goal of this work plan is to provide an overview of the work performed to date and the basis for collection of additional data to support completing the RI/FS and risk assessment for selection of final remedial action(s) for this OU.

1.1 PURPOSE, SCOPE, AND OBJECTIVES

The purpose of this work plan is to describe the approach for completing the RI/FS to support selection of a final remedy for the 200-ZP-1 Groundwater OU. The scope of this project is the collection of data to better define the nature and extent of contamination in the groundwater OU, as well as to collect missing data needed to support risk modeling and screening of remedial alternatives. The scope would also include describing treatability studies; however, there is currently no identified need for site-specific treatability studies.

The project used EPA's *Guidance for the Data Quality Objectives Process* (EPA 2000) to identify the data needs described in this work plan. Both EPA and RL participated in the data quality objectives (DQO) process for this project and generally concurred with the results. Both EPA and RL have agreed that this work plan may require updating as information is obtained from the vadose zone and from RCRA investigations.

The scope of this project is the collection of data to support ultimate remediation/monitoring of the 200-ZP-1 OU. The project's objective is the collection of sufficient data to allow the ultimate selection of one or more appropriate remedial alternatives and to support the associated risk assessment.

1.2 PROJECT GOALS

The primary goal of the investigations described throughout this work plan is to provide the remaining data needed to complete groundwater modeling and risk assessment required to support final remedy selection.

The approach used to provide a basis for these investigations was to examine the existing data for the 200-ZP-1 OU and determine whether additional data are needed from the existing wells, or if additional data need to be collected during installation of the new monitoring wells identified in the *Data Quality Objectives Summary Report for Establishing a RCRA/CERCLA/ AEA Integrated 200 West and 200 East Groundwater Monitoring Network* (FH 2003a).

1.3 DOCUMENT ORGANIZATION

This work plan contains seven sections and three appendices. The body of the document consists of the following sections:

1.0 Introduction
2.0 Site Background and Setting
3.0 Summary of Previous Investigations
4.0 Work Plan Rationale
5.0 Remedial Investigation/Feasibility Study Tasks
6.0 Project Schedule
7.0 References.

Appendices A, B, and C contain the SAP, plate map, and evaluation of historical groundwater data, respectively. The SAP is comprised of a quality assurance project plan and a field sampling plan. The quality assurance project plan includes details regarding the quality assurance (QA) and quality control (QC) required for data collection and evaluation, while the field sampling plan identifies the approach for collecting new data. The QA program has been in use for some time at the Hanford Site; therefore, many of the referenced documents have been reviewed by all parties and are available upon request. The QA system meets EPA guidelines for format and structure (EPA 2001). The methods for data collection and analysis are based on two documents that have been accepted by EPA and RL:

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (SW-846), as amended (EPA 1997)

- *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), (DOE-RL 1998).

This work plan will not regenerate large amounts of existing data that are available elsewhere; rather, this work plan will provide summaries and direct the reader to more detailed documents. Where possible, information is placed in one location in the work plan and cross-referenced to prevent redundancy and facilitate future updates of this document.

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2.0 SITE BACKGROUND AND SETTING

This section provides a general description of the OU, history of operations, and the sources of contamination at the site.

2.1 PHYSICAL SETTING

Seventeen process-based OUs located in the 200 West Area are grouped into four aggregate areas: U Plant, Z Plant, S Plant, and T Plant. The 200 West groundwater aggregate area encompasses groundwater impacted by waste disposal operations at the four source aggregate areas. The 200-ZP-1 Groundwater OU occupies the northern portion of the 200 West groundwater aggregate area. The T Plant and Z Plant groundwater aggregate areas lie largely within that OU. A detailed discussion of the geology and hydrology of the 200 West aggregate area is presented in the *200 West Groundwater Aggregate Area Management Study Report* (AAMSR) (DOE-RL 1993), with more recent analyses found in the *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington* (PNNL 2002b). A summary description of the information found in these reports is provided in the following subsections.

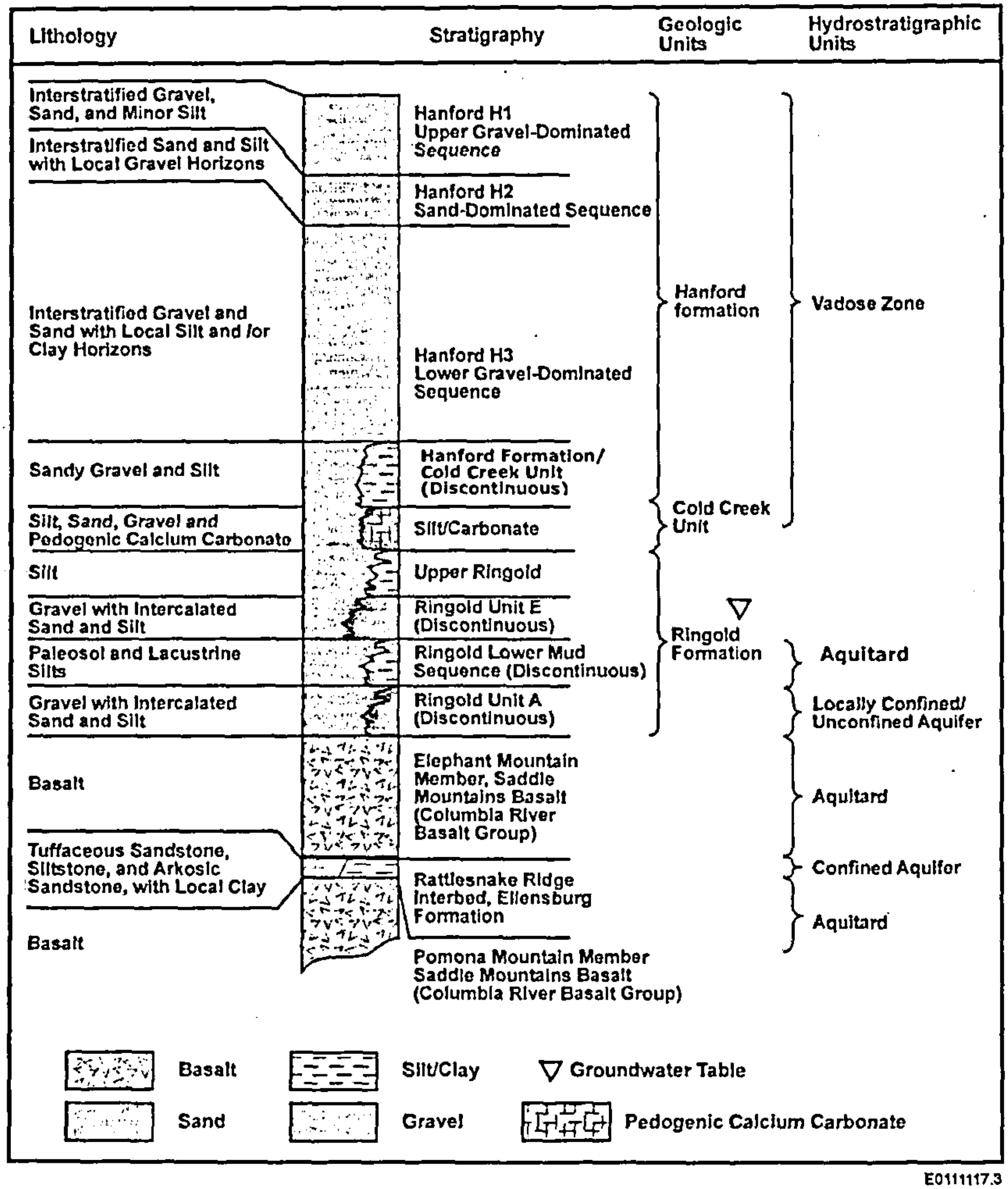
2.1.1 Geology

The geology of the 200-ZP-1 Groundwater OU is characterized by basalt bedrock and sedimentary interbeds overlain by a thick sequence of semi-consolidated late Miocene-age and Cold Creek unit gravels, sands, and silts. The geology of the 200-ZP-1 OU is described in detail in the 200 West groundwater AAMSR (DOE-RL 1993). Additional details can be found in studies for the adjacent 200-UP-1 and 200-UP–2 OUs (*Borehole Summary Report for 200-UP-1 Operable Unit, 200 West Area* [BHI 1995b]; *Borehole Summary Report for 200-UP-2 Operable Unit, 200 West Area* [BHI 1995c] and the revised hydrogeology report [PNNL 2002b]). The reports describe the depths, thickness, and lateral extent of stratigraphic units above the Columbia River Basalt Group. Figure 2-1 illustrates the conceptual geologic and hydrogeologic columns of the major stratigraphic units.

Beneath the 200-ZP-1 Groundwater OU, the primary basalt formations are part of the Columbia River Basalt Group, which are a thick sequence of regionally extensive basalt flows that erupted during the Miocene epoch. The Elephant Mountain Member is the uppermost basalt flow unit beneath the 200-ZP-1 Groundwater OU and is approximately 18 to 36 m (59 to 118 ft) thick. This unit is separated from the underlying Pomona flow by the Rattlesnake Ridge interbed, an approximately 24- to 29-m (80- to 95-ft)-thick sedimentary unit composed of sandstone, siltstone, and clay. The Rattlesnake Ridge interbed and deeper interbeds between basalt flows comprise the Ellensburg Formation. These interbeds and associated Saddle Mountain Basalt flow tops and bottoms form water-bearing zones between basalt flows.

Sediments overlying the basalt in the 200-ZP-1 Groundwater OU are up to approximately 180 m (590 ft) thick and are comprised of, from bottom to top, the Ringold Formation, the Cold Creek unit, the early "Palouse" soils, and the Hanford formation. The Hanford formation sediments are primarily sands with discontinuous silt/sandy silt horizons that may provide platforms for lateral migration in the vadose zone and localized, perched water tables (BHI 1999b). Relatively thin Holocene deposits of eolian sand, loess, alluvium, and colluvium overlie the Hanford formation.

Figure 2-1. Generalized Geologic and Hydrogeologic Column for 200-ZP-1 Groundwater Operable Unit.



The top of the unconfined aquifer in the 200-ZP-1 Groundwater OU occurs in the Ringold Formation. The Ringold Formation in this vicinity consists of fluvial gravels (Ringold Units A and E) and paleosol and lacustrine muds (Ringold Lower Mud sequence). The Ringold Unit A is the lowermost unit and is up to approximately 41 m (135 ft) thick. The Ringold Lower Mud sequence overlies the Ringold Unit A and is up to approximately 33 m (110 ft) thick. The Ringold Unit E overlies the Ringold Lower Mud sequence in the vicinity of the 200 West Area and is up to approximately 88 m (290 ft) thick.

The Cold Creek unit contains calcium carbonate-cemented silt, sand, and gravel and perched water zones in places. Thickness variations in the Cold Creek unit are very irregular. The Cold Creek unit is up to approximately 14 m (46 ft) thick and pinches out south and southwest of the 200 West Area.

The early Palouse soil consists of loess-like silt and minor fine-grained sand. The early Palouse soil is up to approximately 17 m (54 ft) thick, although the thickness of the soils vary irregularly.

The Hanford formation consists of gravel to silt fluvial deposits up to approximately 65 m (210 ft) thick. In the 200 West Area, fine-grained and coarse-grained sediments are locally interbedded and can vary in their dominance based on historical activities that influenced the depositional environment. As noted above, these sediments can create localized perched water tables. In addition, clastic dikes (vertical fracture formations) are present in the Hanford formation and can provide pathways for contaminant migration across and between units (BHI 1999b).

In the 200-ZP-1 Groundwater OU, basalt and overlying sediments dip gently to the southwest toward the axis of the Cold Creek syncline. The Cold Creek syncline is a broad structural depression associated with regional uplifts and other folds.

2.1.2 Hydrogeology

The uppermost aquifer beneath most of the Hanford Site is generally unconfined within the sands and gravels that overlie the basalt bedrock. In some areas, layers of silt and clay confine portions of the aquifer; confined aquifers also occur within the basalt flows themselves and the sedimentary interbeds. Groundwater beneath the Hanford Site flows primarily from recharge areas along the western parts of the Site, to the east and north toward the Columbia River. Flows have historically been modified by the formation of groundwater mounds, created by the discharge of large volumes of process water from Site activities. The elimination of this practice over the last 10 to 20 years has resulted in changes to local groundwater flow patterns and a continuing change to hydraulic conditions more closely approximating pre-Hanford conditions.

The 200 West groundwater AAMSR (DOE-RL 1993) described the primary hydrostratigraphic units in the vicinity of the 200-ZP-1 Groundwater OU as follows:

- Rattlesnake Ridge interbed and deeper interbeds of the Ellensburg Formation (confined water-bearing zones)
- Elephant Mountain Member and deeper flows of the Saddle Mountain Basalt Group (confining horizons for Ellensburg Formation interbeds)
- Ringold Formation (Ringold Unit A, a semi-confined to confined water-bearing zone, Ringold Lower Mud sequence, a confining layer, and Ringold Unit E, an unconfined water-bearing zone, and lower vadose zone).

The revised hydrogeology report (PNNL 2002b) provides additional detail for the unconfined aquifer system, describing the various hydrogeologic units within the Ringold Formation, as well as the overlying Hanford formation. Within the suprabasalt aquifer system, the Pacific Northwest National Laboratory (PNNL) report describes a confining layer of fines (Unit 8) that separates the aquifer into an uppermost unconfined aquifer (Hanford aquifer) and a lower confined aquifer (Ringold aquifer). This confining unit is present throughout most of the 200 West Area, with the exception of those locations approaching Gable Mountain and Gable Gap. The uppermost unconfined aquifer in most of 200 West Area is composed primarily of the gravels of Ringold Unit 5. Contaminant plumes migrate through Ringold Unit 5 and into the overlying Hanford formation. Although the Hanford formation generally overlies the Ringold Formation to the north and east of the 200 West Area, the depositional sequence has resulted in the two formations grading into one another, so flow is possible in a horizontal plane (see Figures 1 through 3 in PNNL 2002b).

Figure 2-2 provides a recent groundwater contour map illustrating the changes to the water table resulting from the elimination of wastewater disposal to ground, as described above (PNNL 2003). Note that although groundwater elevations are declining, the rate of decline is slowing. The rebound effect illustrated by the changes in groundwater contours affects local groundwater flow patterns and can adversely affect the performance of groundwater wells.

In the 200-ZP-1 Groundwater OU, limited borehole data are available for the regionally confined aquifers within the Saddle Mountain Basalt Group, Ellensburg Formation hydrostratigraphic unit. As discussed in the *Quarterly Report of RCRA Groundwater Monitoring Data for Period January 1, 1992 through March 31, 1992* (DOE-RL 1992a), few wells have penetrated the Rattlesnake Ridge interbed (the uppermost basalt sedimentary interbed aquifer) in the vicinity of the 200-ZP-1 Groundwater OU. Limited information regarding hydraulic properties has been collected for this aquifer and deeper confined zones. Although regionally flow is from west to east, there are no wells completed in the confined Ringold aquifer to allow any conclusions regarding flow in that unit beneath the 200 West Area (PNNL 2002b).

Depth to the water table below the 200-ZP-1 OU ranges from approximately 50 m (165 ft) near the southwest corner of the S Plant source aggregate area to more than 80 m (262 ft) near the southeast corner of the T Plant source aggregate area. The thickness of the Ringold Unit A gravels varies from approximately 41 m (135 ft) near the southeast corner of the S Plant source aggregate area to less than 6.4 m (21 ft) near the northwest corner of the U Plant source aggregate area.

2.2 GROUNDWATER CONTAMINANT SOURCES

Numerous sources of liquid waste discharges have existed in the 200 Areas since the inception of activities on the Hanford Site in 1945. Low-level waste was disposed to open trenches and ponds and later flushed with fresh water. Table 2-1 lists the major potential sources of groundwater contamination at the 200-ZP-1 OU.

Summaries of historical operations and disposal practices for T and Z Plants are presented in the following subsections. Detailed information on discharges to these units can be found in a previous DQO summary report (FH 2003a), the Z Plant source AAMSR (DOE-RL 1992c), and the T Plant source AAMSR (DOE-RL 1992b). Documents providing additional historical information are discussed in Section 3.0 of this work plan.

Figure 2-2. Hanford Site and Outlying Areas Water Table Map.

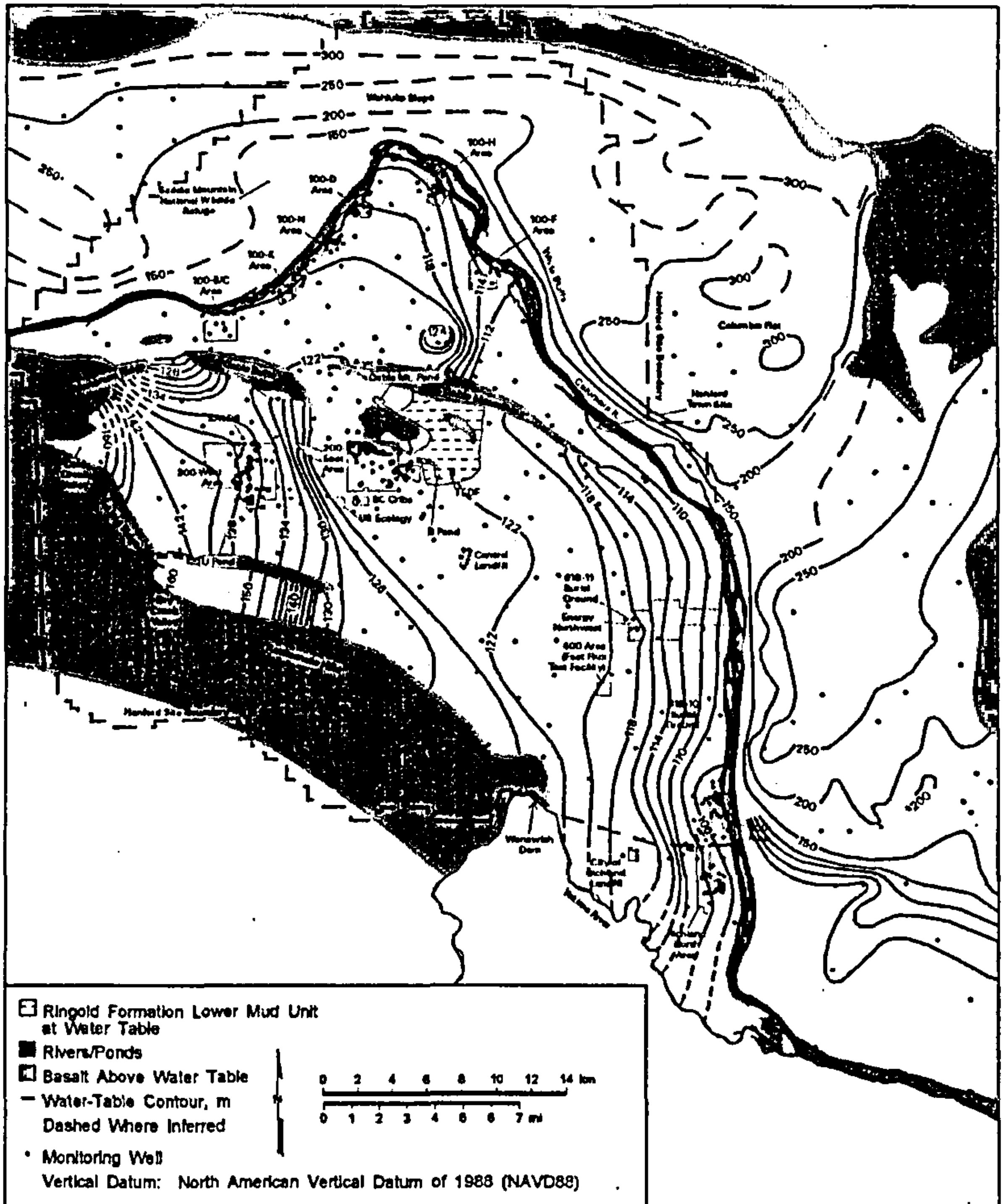


Table 2-1. Potential Sources of Groundwater Contamination at the 200-ZP-1 Operable Unit.[a]

Potential Source of Contamination	Potential Contaminants from Source Area
216-S-25 Crib	Uranium
216-T-7 Crib	Chromium (total), Tc-99
216-T-25 Trench	Tc-99
216-T-26 Crib	I-129, nitrate, Tc-99
216-T-28 Crib	I-129, nitrate, Tc-99
216-T-32 Crib	Chromium (total), Tc-99
216-Z-1A tile field	Carbon tetrachloride, chloroform, TCE, nitrate
216-Z-9 Trench	Carbon tetrachloride, chloroform, TCE, nitrate
216-Z-18 Crib	Carbon tetrachloride, chloroform, TCE, nitrate
218-W-4C WIDS site	Cadmium
Agricultural activities upgradient from Hanford Site	Nitrate
T, TX, TY Tank Farms	Chloroform, TCE, Tc-99, tritium, fluoride
T Plant	Uranium, tritium
T Evaporator	Tritium
T Plant disposal facilities (miscellaneous)	Tritium
Z Plant BP WIDS Site	Cadmium

[a] Data obtained from *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE-RL 2002).
TCE = trichloroethylene
WIDS = Waste Information Data System

While the source OUs are not the focus of this study, it must be noted that source OUs were originally grouped geographically. In 1996, the source OUs were regrouped into 23 process OUs. Thus, the AAMSRs provide good background information but not the current OU grouping.

2.2.1 Historical Operations, Disposal Practices, and Waste Management Units

2.2.1.1 T Plant

The T Plant was built in 1944 and operated as one of the first separation facilities at the Hanford Site. The 221-T Building (also known as the T Plant or T Canyon Building) housed the first operational, full-scale, bismuth phosphate separation facility in the world. The dilute plutonium nitrate solution generated through this process was transferred to the 224-T Bulk Reduction Building where it was purified to reduce volume using the lanthanum fluoride process. Operations in the 221-T and 224-T Buildings ceased in 1956. Primary waste streams from the 221-T and 224-T Buildings included process waste and aqueous process waste that were discharged to tanks, cribs, and trenches. Decontamination wastewater was discharged to a crib. The associated analytical laboratory, which operated from 1944 to 1956, produced aqueous process waste that was discharged to a crib.

The 221-T Building was used for a series of testing programs from 1964 to 1990. The beginning portion of the process facility of 221-T housed the Containment Systems Testing Facility from 1964 through 1969. These programs were managed by Pacific Northwest Laboratory from 1964 to 1969, and by Westinghouse Hanford Company from 1976 to 1990. Current operations in the 221-T Building include services in radioactive decontamination and reclamation, as well as decommissioning of process equipment. T Plant will receive sludge from the cleanout of K Basin.

Plutonium scrap in liquid and solid forms was stored in the 224-T Building beginning in the early 1970s. The scrap was removed from the 224-T Building in 1985 (although the building was not decontaminated) when it was officially designated the Transuranic Waste Storage and Assay Facility. The storage area, an old processing hood, and all of the piping associated with plutonium-separation processing remain entombed in the building. The Transuranic Waste Storage and Assay Facility operation consists of nondestructive assay and nondestructive examination of newly generated, contact-handled transuranic solid waste packages for general compliance with the Waste Isolation Pilot Plant waste acceptance criteria requirements.

2.2.1.2 Z Plant Aggregate Area

The Z Plant began operation in 1945 as the Plutonium Isolation Facility, which concentrated plutonium nitrate solution produced by either of the separation facilities (T Plant or B Plant) and converted the concentrate to a plutonium nitrate paste for shipment to Los Alamos, New Mexico for further refinement. This operation took place from 1945 to 1949. Primary waste streams from the Plutonium Isolation Facility included process waste and wastewaters that were discharged to a ditch, several cribs, and a reverse well.

In 1949, the 234-5 (or Z Plant) was constructed to produce plutonium metal. The 234-5, or Z Plant Complex (also referred to as the Plutonium Finishing Plant [PFP]), operated from 1949 to 1973, and then intermittently from 1985 to 1988. This plant processed the plutonium from the 200 East and 200 West separation facilities to a plutonium metal and/or plutonium oxide. Primary waste streams from the PFP included process waste and wastewaters that were discharged to cribs, tanks, ponds, ditches, and seepage basins.

Plutonium recovery facilities also operated in the Z Plant process area. These included the Recovery of Uranium and Plutonium by Extraction (RECUPLEX) Facility (234-5Z Building), which operated from 1955 to 1962, and the Plutonium Reclamation Facility (PRF) (236-Z), which operated from 1964 to 1979 and from 1984 to 1987. These facilities recovered plutonium from the PFP liquid waste stream. The primary waste streams from the RECUPLEX Facility included aqueous process waste, organic solvent waste, and spent silica gel that were discharged to a ditch, pond, trench, and french drain. The primary waste streams from the PRF included aqueous process waste and organic process waste that were discharged to trenches, cribs, and tile fields. The RECUPLEX Facility was shut down after a criticality event in 1962.

A process line also operated in the 242-Z Building from 1949 to 1959, and again from 1964 to 1976, to recover americium from the PFP waste stream. The primary waste stream from the americium recovery was spent ion-exchange resin that was discharged to ditches and a pond. The americium recovery process also generated an organic waste stream (carbon tetrachloride and dibutyl butyl phosphonate). This facility shut down after an explosion in 1976 in one of the recovery units.

An analytical laboratory has operated at Z Plant from 1955 to the present. The primary waste stream from the laboratory includes process wastes, used or discarded reagents, and wastewater discharged to cribs.

The *200-ZP-1 IRM Phase II and III Remedial Design Report* (DOE-RL 1996b) states that between 1955 and 1973, an estimated 600,000 to 900,000 kg of carbon tetrachloride were discharged to the soil column within the 200-ZP-1 OU. The total estimated mass of dissolved carbon tetrachloride, trichloroethylene (TCE), and chloroform in groundwater was estimated at 4,400 kg, 0.14 kg, and 30.6 kg, respectively.

The pump-and-treat system for the 200-ZP-1 OU, located near the PFP, was implemented in accordance with the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA et al. 1995). The interim remedial action objectives (RAOs) are as follows:

- Prevent further movement of contaminants from the highest concentration area of the carbon tetrachloride plume (i.e., >2,000 µg/L contour).
- Reduce contamination in the area of highest carbon tetrachloride concentrations.
- Provide information that will lead to the development of a final remedy that will be protective of human health and the environment.

The pump-and-treat operations were implemented in a three-phased approach. Phase I operations consisted of a pilot-scale treatability test from August 29, 1994, through July 19, 1996. During the testing period, contaminated groundwater was removed from a single extraction well, treated using granular activated carbon (GAC), and then returned to the aquifer through an injection well. For more detailed information about operations during the treatability test, refer to the *200-ZP-1 Operable Unit Treatability Test Report* (DOE-RL 1995).

Phase II operations commenced August 5, 1996, and ended on August 8, 1997, for transition to Phase III operations. The well configuration during Phase II operations consisted of three extraction wells that were completed in the top 15 m (49.2 ft) of the aquifer. The groundwater was treated using an air stripper, followed by GAC treatment of the air stream. The groundwater was then returned to the aquifer through a single injection well.

From August 8 through August 28, 1997, well field piping and treatment equipment were upgraded for Phase III operations, which were initiated on August 29, 1997. The well configuration was expanded to six extraction wells (in the top 15 m [49.2 ft] of the aquifer) and five injection wells. The extraction wells included 299-W15-33, 299-W15-34, 299-W15-35, 299-W15-32, 299-W15-36, and 299-W15-37. The injection wells included 299-W15-29, 699-39-79, 299-W18-36, 299-W18-37, 299-W18-38, and 299-W18-39. The Phase III treatment system uses air stripping combined with vapor-phase GAC technology to remove the volatile organic compounds (VOCs) from the contaminated groundwater. Extraction well 299-W15-37 was taken off-line in February 2001.

Carbon tetrachloride contamination in the groundwater was reduced in the area of highest concentrations through mass removal. Over 301 million L of contaminated groundwater were treated in fiscal year 2002 (FY02) at an average flow rate of 573 L/min. The average influent concentration for the extraction wells was 3,356 µg/L (DOE-RL 2003a).

Treatment of the contaminated water resulted in the removal of 1,053 kg (2,319 lb) of carbon tetrachloride in FY02. Between the initiation of pump-and-treat operations in August 1994 and the end of FY02, approximately 1.89 billion L of water had been treated, resulting in the removal of 6,849 kg (15,086 lb) of carbon tetrachloride (DOE-RL 2003a).

The following conclusions can be drawn from changes in the carbon tetrachloride plume maps (see DOE-RL 2003a for additional information):

- The plume center is moving primarily in a northerly and easterly direction, toward the four northernmost extraction wells.
- Concentrations of carbon tetrachloride south and east of injection well 299-W15-29 are decreasing, which implies that injection of the treated water is displacing the plume to the east.
- General groundwater flow near the extraction wells remains east-northeast in this area. Water levels are estimated to be declining in this area at a rate of about 0.36 m/yr (1.2 ft/yr) (DOE-RL 2003a).

2.2.2 Potential for Liquid Discharge to the Unconfined Aquifer

The potential for each waste management unit (WMU) to contribute liquids to the unconfined aquifer in the past was assessed based on soil pore volume screening calculations and examinations of geophysical logs (gross gamma rays and spectral gamma). Conclusions of this screening assessment are presented in Table 2-2 of the 200 Area groundwater AAMSR (DOE-RL 1993). The primary purpose of the screening was to flag any WMU that received a volume of liquid waste greater than a conservatively high estimate of the soil pore volume beneath the unit or any unit where geophysical logging indicated radionuclides had contributed to groundwater contamination. The 200 West groundwater AAMSR discusses the rationale for these screening criteria; screening criteria assumptions and details are presented in Tables 2-2 and 2-3 of the same document (DOE-RL 1993). This analysis does not take into account the long-term drainage that may be occurring at any of the sites that received liquid waste. The screening criteria indicate potential for liquids discharged to the following WMUs in the Z Plant source aggregate area to have reached the groundwater table:

- 216-Z-1, 216-Z-2, 216-Z-3, 216-Z-5, 216-Z-7, 216-Z-12, 216-Z-16, and 216-Z-18 Cribs
- 216-Z-8 french drain
- 216-Z-1 tile field
- 216-Z-10 reverse well
- 2607-Z septic tank/drain field
- 216-Z-9 and 216-Z-17 Trenches
- 231-Z-151 sump.

Effluent discharges to the sediment column have been phased-out over the last decade. Effluent discharges to the sediment column in the 200 West Area were terminated in June 1995 (DOE-RL 1996c). Stopping discharges results in a reduction of vadose moisture, which is the primary mechanism of transport to groundwater. Observations in the 200 West Area indicate that it may take several years for vadose zone sediments to return to approximately natural moisture conditions following the end of water disposal at a facility (DOE-RL 1996c).

Section 3.0 provides a summary of the investigations that have been initiated or completed to evaluate the nature and extent of contamination within the 200-ZP-1 Groundwater OU.

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3.0 SUMMARY OF PREVIOUS INVESTIGATIONS

3.1 CERCLA PROCESS HISTORY FOR THE 200-ZP-1 OPERABLE UNIT

Since 1993, active evaluations of the source term, vadose zone, and groundwater have led to the groundwater ROD (EPA et al. 1995) and interim remedial measures (IRMs) (DOE-RL 1996b). Many of the documents supporting the history to this point are listed (alphabetically by document title) in Table 3-1, including a summary of the documents' contents. This reference list is presented to allow the reader to understand the regulatory, characterization, and evaluation that have previously been performed.

It should be noted that an IRM was undertaken for the carbon tetrachloride plume in the 200-ZP-1 OU and, to date, no limited field investigation has been initiated. The IRM has a complete group of work plans, sampling requirements, and data assessment requirements that are not part of the scope of this work plan.

Table 3-1 also lists select Hanford Sitewide groundwater documents that provide information pertinent to and including the 200-ZP-1 OU. Modeling will be performed to assess the transport from the vadose zone to the groundwater and to assess groundwater transport. Modeling of the vadose zone to groundwater is part of another project, but data from this modeling will be an input to the tasks in this work plan; thus, pertinent background references for modeling are also listed in Table 3-1.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program, DOE/RL-98-28, Rev. 0 (DOE-RL 1999)	The Implementation Plan outlines the framework for implementing assessment activities in the 200 Areas to ensure consistency in documentation, level of characterization, and decision making. The Implementation Plan also consolidates background information and other typical work plan materials to serve as a single reference source for this type of information. This Implementation Plan does not provide detailed information about the assessment of individual waste sites or groups. Site-specific data needs, DQOs, data collection programs, and associated assessment tasks and schedules will be defined in subsequent group-specific (i.e., OU-specific) work plans. A common regulatory framework is established that integrates the RCRA, CERCLA, *Federal Facility Regulations*, and Tri-Party Agreement requirements into one standard approach for 200 Area cleanup activities. The Implementation Plan also streamlines work plans that are required for each waste site group by consolidating background information to provide a single referenceable source for this information. This allows the information in the group-specific work plans to focus on waste group or waste site-specific information. The background information includes an overview of the 200 Area facilities and processes, their operational history, contaminant migration concepts, and a list of COCs. It also documents and evaluates existing information to develop a site description and conceptual model of expected site condition and potential exposure pathways. With this conceptual understanding, preliminary potential ARARs, preliminary RAOs, and remedial action alternatives are identified. The alternatives are broadly defined but represent potential alternatives that may be implemented on at the site. The identification of potential alternatives helps to ensure the data needed to fully evaluate the alternatives are collected during the RI. The specific type and quality of data are to be defined through the site-specific DQOs and form the basis for the data collection programs. The 200 Areas strategy recognized the inter-relationships between the various activities in the area and the need to integrate with other Environmental Restoration and Hanford Site projects/programs. The Implementation Plan describes the approach for interfacing with other programs and agencies, the integrated schedule of activities that addressed both RCRA and CERCLA program requirements, and the public participation process.
200 West Groundwater Aggregate Area Management Study Report, DOE/RL-92-16, Rev. 0 (DOE-RL 1993)	Evaluates various sources and COPCs applicable to the OU. See Section 3.2 of this work plan for a summary of this document.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
200-ZP-1 Groundwater Sampling and Analysis Plan/Quality Assurance Plan, BHI-00038, Rev. 1 (BHI 1995a)	This SAP provides the rationale for development of three monitoring network designs (i.e., remedial action, plume periphery, and detection-level assessment networks), the DQOs associated with each design, the specifics for each network (i.e., wells, sampling schedules, and parameters), and supporting work that influences future network modifications. Requirements that address the treatability test groundwater monitoring phase of this investigation are detailed in Rev. 0 of this SAP. Treatability testing was completed on March 31, 1995. Each of these three monitoring networks is designed to address general and specific DQOs. The well networks are nested in areas of high contamination (remedial action assessment wells), low contamination (plumes periphery assessment wells), and where no contamination has been detected (detection-level assessment wells). Monitoring wells selected for each category may change over the course of the IRM to reflect remedial action activities. The network closest to the area of highest contamination will likely change the most as the IRM develops. The SAP also presents the 1995 perimeter of the carbon tetrachloride plume within the 200-ZP-1 OU and identifies the wells to be sampled for remedial action assessment and to track the plume periphery. It identifies the sampling frequency, the analyses to be performed, and a list of wells from which groundwater-level measurements will be collected.
200-ZP-1 IRM Phase II and III Remedial Design Report, DOE/RL-96-07, Rev. 1 (DOE-RL 1996b)	The 200-ZP-1 remedial design report presents the objectives and rationale developed for the design and implementation of the selected IRM for the 200-ZP-1 OU. The IRM was chosen in accordance with CERCLA. This remedial design report addresses the design for "Alternative 2, Groundwater Pump-and-Treat System." The goal is to reduce further migration of carbon tetrachloride, chloroform, and TCE in the groundwater of the 200 West Area. The Phases II and III IRM treatment system will be designed to hydraulically contain and reduce the contaminant mass in the high-concentration portion (i.e., the 2,000 to 3,000 ppm contour) of the carbon tetrachloride plume. The 200-ZP-1 IRM consisted of three phases. The Phase I treatment system, which originated as a treatability test, began operations in August 1994 south of the 234-5Z Plant. The Phase I treatment system provided a 227 L/min (60 gpm) treatment capacity using liquid-phase GAC to remove organic contamination from the extracted groundwater. One extract well and one injection well provided the groundwater inlet stream and treated effluent disposal functions for the system. Successful results from the Phase I treatment system treatability test resulted in continued operation until startup of the Phase II treatment system. The objective of the Phase II treatment system was to initiate hydraulic containment of the 2,000 to 3,000 ppb contour of the carbon tetrachloride plume. The Phase II treatment was located north of the 234-5Z Plant and will use air stripping and vapor-phase GAC adsorption. The objective of the Phase II treatment system is to further contain the high-concentration portion of the contaminant plume. The Phase III treatment system will upgrade the Phase II treatment system to a process flow rate of up to 1,893 L/min (500 gpm) by adding required extraction and injection wells and associated piping runs.
Assessment of Carbon Tetrachloride Groundwater Transport in Support of the Hanford Carbon Tetrachloride Innovative Technology Demonstration Program, PNNL-13560 (Truex et al. 2001)	Includes a literature review of distribution coefficients and abiotic hydrolysis degradation rates for carbon tetrachloride. See Section 3.4 of this work plan for additional details.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
Carbon Tetrachloride Field Investigation Report for Drilling in the Vicinity of PFP and the 216-Z-9 Trench, BHI-01631, Rev. 0 (BHI 2002a)	In 2001, two existing wells near the 216-Z Trench were deepened to characterize the distribution of carbon tetrachloride at the waste site. The deepened wells were completed as soil vapor extraction wells to enhance vadose zone remediation activities. In February 2002, a groundwater extraction/monitoring well was installed in the vicinity of PFP to evaluate the distribution of carbon tetrachloride at the site and to potentially enhance groundwater remediation activities. This report provides soil, soil vapor, and groundwater sampling results from deepening of wells 299-W15-84 and 299-W15-95 at the 216-Z-9 Trench, and information related to the drilling of wells 299-W15-42 and 299-W15-764 inside the PFP protected area. It also provides an evaluation of the then current conceptual models of the 216-Z-9 Trench and surrounding area using hydrological and chemical/geochemical data from the deepened wells in addition to data from nearby wells to assess subsurface contaminant distribution and refine the site conceptual model.
Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, PNNL-11800 (Kincaid et al. 1998)	A composite analysis was prepared for the Hanford Site considering only sources in the 200 Area Plateau. Estimating doses to hypothetical members of the public for the composite analysis was a multi-step process involving the estimation or simulation of inventories; waste release to the environment; migration through the vadose zone, groundwater, and atmospheric pathways; and exposure and dose. Doses were estimated for based on the agriculture, residential, industrial, and recreational land-use scenarios. The radionuclides included in the vadose zone and groundwater pathway analyses of future releases were carbon-14, chlorine-36, selenium-79, technetium-99, iodine-129, and uranium isotopes. In addition, tritium and strontium-90 were included because they exist in groundwater plumes. Radionuclides considered in the atmospheric pathway included tritium and carbon-14. The analysis indicated that most of the radionuclide inventory in past-practice liquid discharge and solid waste burial sites on the 200 Area Plateau was projected to be released in the first several hundred years following Hanford Site closure. The radionuclide doses for all of the exposure scenarios outside of a defined buffer zone were all less than 3 mrem/yr, which is well below the performance objectives of 100 mrem/year or the ALARA objective of 30 mrem/year. Several sources of uncertainty were noted in the first iteration of the composite analysis, with the largest uncertainty associated with the inventories of key mobile radionuclides. Other sources of uncertainty in the analysis arose from the conceptual and numerical models of contaminant migration and fate in the vadose zone and assumption regarding source-term release models and end states. The composite analysis demonstrated a significant separation in time between past-practice discharges and disposals, and active and planned disposal of solid waste, environment restoration waste, and immobilized low-activity waste. The higher integrity disposal facilities and surface covers of these active and planned disposal delay releases, and the releases do not superimpose on the plumes from the near-term past-practice disposals. See Section 5.3 of this work plan for an additional discussion of the anticipated use of the SAC in the 200-ZP-1 Groundwater OU.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
Data Quality Objective Summary Report for Establishing a RCRA/CERCLA/AEA Integrated 200 West and 200 East Area Groundwater Monitoring Network, CP-15329, Rev. 0 (FH 2003a)	The purpose of this DQO process was to assess the current groundwater monitoring well networks for the 200 West and 200 East Areas. This assessment was needed to address changing contaminant plume conditions (e.g., plume migration) and to ensure that monitoring activities meet the requirements for remediation performance monitoring (i.e., CERCLA monitoring), Sitewide surveillance monitoring to meet the requirements of DOE orders, and detection/assessment monitoring to meet the requirements of RCRA. This DQO summary report was prepared in support of DOE's Cleanup, Constraints, Challenges Team (C3T) process. Because of the changing shape of the groundwater contaminant plume contours over time and changing programmatic needs, the 200 West and 200 East groundwater monitoring network is required to be periodically re-evaluated. The objective of the groundwater CERCLA remediation performance monitoring program is to provide a routine assessment of the effectiveness of groundwater remediation activities within the 200-ZP-1 and 200-UP-1 OUs. The objectives of the Sitewide surveillance-monitoring program are as follows: • Determine baseline conditions of groundwater quality and quantity. • Characterize and define hydrogeologic, physical, and chemical trends in the groundwater system. • Identify existing and potential groundwater contamination sources. • Assess existing and emerging groundwater quality problems. • Evaluate existing and potential offsite impacts of groundwater contamination. • Provide data on which decisions can be made concerning land disposal practices and the management and protection of groundwater resources. Finally, the objective of the RCRA detection program is to identify if TSD units are impacting groundwater quality. If impacts to groundwater are detected, the objective of the RCRA assessment program is to define the rate and extent of contaminant migration. This DQO process identified the optimum number of groundwater wells to be monitored to meet these objectives and determined that a number of new groundwater wells needed to be installed. The identity of wells in the monitoring network, sampling frequency, the analyses to be performed, the detection limit requirements, and other analytical performance requirements (e.g., precision and accuracy) were defined in this document. The resulting groundwater monitoring network fulfilled the needs of the three major Hanford Site regulatory monitoring activities (i.e., CERCLA, RCRA, and AEA).

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit (EPA et al. 1995)	The interim ROD for the 200-ZP-1 OU presents a description of the selected interim remedy for carbon tetrachloride, chloroform, and TCE groundwater contamination in the vicinity of the PFP. The interim remedial action was chosen in accordance with CERCLA, SARA, the Tri-Party agreement and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. The State of Washington concurred with the selected remedy. The selected remedy consists of pumping the highest concentration zone of the contaminated plume at 200-ZP-1 and treatment using a vapor extraction system. The selected remedy is intended to reduce contaminant mass within the plume and minimize migration of carbon tetrachloride, chloroform, and TCE from the 200 West Area. The high-concentration portion of the plume corresponds to that area having contaminant greater than or equal to 2,000 ppm carbon tetrachloride. The interim action is protective of human health and the environment in the short term and is intended to provide adequate protection until a final ROD is signed. The groundwater removed will be treated to meet requirements before discharge. This interim action is only part of the total remedial action for the 200-ZP-1 OU and is considered cost effective. The interim RAOs are as follows: • Prevent further movement of contaminants from the highest concentration area of the carbon tetrachloride plume (i e., >2,000 µg/L contour). • Reduce contamination in the area of highest carbon tetrachloride concentrations. • Provide information that will lead to the development of a final remedy that will be protective of human health and the environment.
Findings from Groundwater Compliance Monitoring Evaluation Inspection at the T and TX/TY Waste Management Areas, letter from B. Wilson (Ecology) to K. Klein (RL) and H. Boston (ORP), dated November 20, 2001 (Wilson 2001)	This letter reported that neither the vertical nor horizontal extent of contamination to groundwater in the T or TX/TY TSD units have been delineated in accordance with 40 CFR 265.93(d)(4)(i), Subpart F. The letter notes that unfiltered groundwater samples should be collected when in situ turbidity measurement goals have been reached.
Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations, DOE/RL-2002-67, Rev. 0 (DOE-RL 2003a)	The document summarizes performance of the groundwater pump-and-treat systems in FY02 and discusses the changes that have been observed in the plume shape and concentration during the reporting period. See Section 2.2.1.2 of this work plan for a more detailed discussion of the document and other precursor documents.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection, DOE/RL-2002-68, Rev. 0 (DOE-RL 2003b)	This document lays out a plan developed by DOE, in conjunction with EPA and Ecology, to accelerate cleanup. The goal is to return groundwater to its highest beneficial use, where practicable, or which will at least prevent further degradation. The previous baseline shows remediation beginning in 2008 and extending to 2024. The new accelerated schedules illustrated in this document show that the baseline will begin in 2004 and be completed by 2012. The document contains discussion of specific results that can be expected using the accelerated plan for cleanup. These results and expected dates of completion include the following: • Remediate high-risk wastes: 2011. • Shrink the contaminated areas: 2112. • Reduce recharge: 2012. • Remediate groundwater: 2012. • Evaluate groundwater monitoring needs: ongoing. Plans to deal with waste sites in close proximity to the tank farms require further work and will depend greatly on the strategy employed to close the tanks. The regions selected for completion by 2012 avoid those areas immediately adjacent to tank farms until and integrated approach to waste site remediation and tank closure can be developed. In addition to accelerated schedules for cleanup and groundwater protection, the document contains definition and discussion of various proposed groundwater protection boundaries (e.g., core zone and outside the core zone). As part of the integrated accelerated plan, an area closure strategy for the Central Plateau is discussed. Three major areas in the 200-ZP-1 Groundwater OU are identified: • T Plant area closure • T-Tank Farm area closure • PFP area closure. When cleanup is implemented on an area-by-area basis, these coordinated efforts to control sources, implement remedial action, and assess and monitor impact are expected to place major portions of the Central Plateau into a condition of long-term stewardship monitoring starting in 2006.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
Hanford Site Groundwater Monitoring for Fiscal Year 2002, PNNL-14187 (PNNL 2003)	This report presents the results of groundwater and vadose zone monitoring and remediation for FY02 on the Hanford Site. Water-level monitoring was performed to evaluate groundwater flow directions, to track changes in water levels, and to relate such changes to evolving disposal practices. Water levels over most of the Hanford Site continued to decline between March 2001 and March 2002. The most extensive plumes are tritium, iodine-129, and nitrate, which all had multiple sources and are mobile in groundwater. The largest portions of these plumes are migrating from the central Hanford Site (Central Plateau) to the southeast, toward the Columbia River. Concentrations of tritium, nitrate, and some other contaminants continued to exceed drinking water standards in groundwater discharging to the river in FY02. However, contaminant concentrations in river water remained low and were far below standards. Carbon tetrachloride and associated organic constituents form a relatively large plume beneath the central portion of the Hanford Site. Hexavalent chromium is present in smaller plumes beneath the reactor areas along the river and beneath the central portion of the Site. Strontium-90 exceeds standards beneath each of the reactor areas, and technetium-99 and uranium are present in the 200 Areas. Other minor contaminant plumes are also noted. Interim groundwater remediation in the 100 and 200 Areas continued in 2002. The objective of the two interim remediation (pump-and-treat) systems in the 200-ZP-1 and 200-UP-1 Groundwater OUs in the 200 West Area is to prevent the spread of carbon tetrachloride and technetium-99/uranium plumes. This annual report presents groundwater contours and the perimeter of the carbon tetrachloride, chloroform, and TCE plumes within the 200-ZP-1 OU, as well as groundwater contours and the perimeter of the technetium-99 and uranium plumes within the 200-UP-1 OU. Also provided are maps showing the location of sampled groundwater wells and the frequency at which wells are sampled, the depth of well screens, etc. A set of computer models known as the SAC simulates movement of contaminants from waste sites through vadose zone and groundwater. In FY02, modelers completed an initial assessment of 10 contaminants, simulating their movement over the years 1944 through 3050. Specific modeling of plume movements in the 200 Areas and local-scale modeling of the 200 Area pump-and-treat IRMs were reported.
Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/ Technetium Plumes in the 200 West Area: 1994 Through 1999 Update, BHI-01311, Rev. 0 (BHI 1999b)	Summarizes the geological and hydrogeological conceptual model for the carbon tetrachloride plume in the 200 West Area. Includes a summary of analytical results for carbon tetrachloride sampling (through 1999) at depths greater than 10 m (32.8 ft) below the water table. See Section 3.3 of this work plan for additional details.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
An Initial Assessment of Hanford Impact Performed with the System Assessment Capability, PNNL-14027 (Bryce et al. 2002)	In 1999, DOE initiated the development of an assessment tool that will enable users to model the movement of contaminants from all waste sites at Hanford through the vadose zone, groundwater, and Columbia River and to estimate the impact of contaminants on human health, ecology, and the local cultures and economy. This tool was named the "System Assessment Capability (SAC)." An assessment was recently completed with the SAC that demonstrates it is a functional assessment capability. Future modifications to the tool will be driven by the requirements of specific assessments. Results will continue to improve as input data are refined through characterization and scientific research. The results of the first runs performed with SAC were presented to the Integration Project Expert Panel. Analysis performed on these early results identified a number of issues that needed to be addressed before the tool could be considered useful. The major issues were addressed by replacing a simple two-dimensional groundwater model in the SAC with the three-dimensional Sitewide Hanford groundwater model, correcting the quantity of contaminant assigned to several waste sites, and obtaining more efficient hardware for performing analyses. Following the implementation of those changes, the assessment was re-run, resulting in the following: • Modeled the movement of contaminants from more than 500 locations throughout the Hanford Site, representing 890 waste sites through the vadose zone, groundwater, and Columbia River. • Incorporated data on 10 radioactive and chemical contaminants (carbon tetrachloride, cesium-137, chromium, iodine-129, plutonium-239/240, strontium-90, technetium-99, tritium, total uranium, and uranium-238). • Focused on subsurface transport, the Columbia River, and risks to human and ecological health, and the economy and culture. See Section 5.3 of this work plan for an additional discussion of anticipated use of the SAC in the 200-ZP-1 Groundwater OU.
Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-1 Operable Unit Phase I Representative Waste Sites, BHI-01477, Rev. 0 (BHI 2001)	This Phase I DQO summary report supported the remedial action decision-making processes for the 200-PW-1 organic-rich/plutonium-rich waste group OU. The RI was to be conducted under CERCLA. The waste sites in the 200-PW-1 OU received effluents from the Z Plant complex, including PFP processes, which contained significant concentrations of chemicals and radionuclides. Data collected during the RI was to be used to determine if the waste sites were contaminated above levels that will require remedial action, to support evaluation of remedial alternatives and/or closure strategies, and to verify or refine the preliminary conceptual contaminant distribution models. The data were generated mainly through soil sampling and analysis. The DQO process used the concept of analogous site contaminant data to reduce the amount of characterization required to support RI/FS decisions. This approach involves the grouping of sites with similar process histories, structures, and contaminants and then choosing one or more representative sites for comprehensive field investigation, including sampling during the RI activities. Findings from the RI at representative sites are then used to make remedial action decisions for all of the waste sites in the OU. Nonrepresentative sites for which field data have not been collected are assumed to have contaminant characteristics similar to the representative sites that are characterized. A ROD will be issued through the RI/FS process using the data collected during the RI. The analogous sites (i.e., those not sampled during the RI) will be addressed during the confirmatory sampling phase to ensure that the remedial action specified in the ROD is appropriate and to provide design data as needed. Following remedial actions, verification samples will be collected to support site closeout.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
"Summary of Comprehensive Groundwater Monitoring Evaluation Report, T and TX-TY Tank Farms," March 1, 2001 (contained in the *Data Quality Objectives Summary Report for Establishing a RCRA/CERCLA/ AEA Integrated 200 West and 200 East Groundwater Monitoring Network* [FH 2003a])	This document notes that in 1996, there were statistically significant increases in chromium, technetium-99, and cobalt-60 in well 299-W11-27, which is located on the north side of TSD unit T. The plume that affected well 299-W11-27 is now being detected in well 299-W11-23, located to the east of 299-W11-27. The TX-TY TSD unit was placed in assessment groundwater monitoring (40 CFR 265.93[d][4]) after elevated waste constituent and indicator parameter measurements/observations (specific conductivity) occurred in downgradient monitoring wells. Elevated levels of chromium, tritium, technetium-99, and cobalt-60 were observed in samples from well 299-W14-12, which is located on the east side of TSD unit TX-TY. In 1998, a tritium and ioding-129 plume was detected in well 299-W14-2, located on the east side of TSD unit TX-TY. <u>TX TANK FARM</u> Eight TX Tank Farm tanks (TX-105, TX-107, TX-110, TX-113, TX-114, TX-115, TX-116, and TX-117) are "suspected/confirmed leaking single-shell tanks." At least 10 UPRs have been documented within the vicinity of the TSD unit TX: • UPR-200-W-5 occurred in 1950 and resulted from leaky jumpers/overflow around the 251-TX-155 diversion box (Barry 1997, WIDS). • UPR-200-W-126 occurred in 1975 during repair of 241-TX-153. The UPR was a liquid spill on the east side of the TX Tank Farm (Barry 1997, BHI 1995d, WIDS). • UPR-200-W-129 occurred in 1971 during testing of jumpers at the 241-TX-113 tank. This UPR occurred while a new jumper assembly was being leak tested. Apparently a valve was inadvertently closed, which caused contaminated liquid to spray through the pit cover blocks. The extent of the contamination was not documented (Barry 1997, WIDS). • UPR-200-W-149 occurred in 1977 and consisted of a suspected leak from 241-TX-107 tank after high monitoring counts in gross-gamma log of dry well were detected. A reported 2,500 gal of waste leaked from this tank (Barry 1997, WIDS). • UPR-200-W-17 occurred in 1952 and consisted of a spill during transfer/pumping from the 241-TX-106 to 241-TX-114 tank. The contaminated material covered an area 9.5 m by 182.9 m (300 ft by 600 ft). The contaminated liquid contained concentrations of cesium-137, nobelium, ruthenium, strontium-90, and zirconium (Barry 1997, WIDS). • UPR-200-W-29 occurred in 1954 and consisted of the failure of an unencased line connecting 241-T-152 and 241-TX-153 diversion boxes, during which first-cycle supernatant from 241-T-105 tank was released (Barry 1997, WIDS). • UPR-200-W-100 occurred in 1954 when waste spilled from the line connecting the 241-TX-105 and 241-TX-118 tanks. Contaminated liquid from the leak covered an area approximately 30.3 m by 38.13 m (100 ft by 125 ft). The contaminated liquid contained approximately 10 Ci of fission products (Barry 1997, WIDS). • UPR-200-W-135 occurred in 1954 and consisted of a leak (approximately 1,000 gal of supernatant) north of the 241-TX-155 diversion box (Barry 1997, WIDS). • UPR-200-W-99 occurred in 1968 as a result of airborne contamination that emanated from the 241-TY-153 diversion box. Two plumes containing strontium-90 were identified northeast and southeast of the diversion box. This UPR lies just outside the east TX Tank Farm fence (Barry 1997, WIDS). • UPR-200-W-76 occurred in 1997 and consisted of contaminated rabbit fecal pellets that covered an area 45.75 m by 91.5 m (150 ft by 300 ft) in the northwest corner of the tank farm. The fecal mater contained cesium-137, cesium-134, europium-152, europium-154, and strontium-90 (Barry 1997, WIDS).

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
[continued] "Summary of Comprehensive Groundwater Monitoring Evaluation Report, T and TX-TY Tank Farms," March 1, 2001 (contained in the *Data Quality Objectives Summary Report for Establishing a RCRA/CERCLA/ AEA Integrated 200 West and 200 East Groundwater Monitoring Network* [FH 2003a])	<u>TY TANK FARM</u> Five TY Tank Farm tanks (TY-101, TY-103, TY-104, TY-105, and TY-106) are "suspected/confirmed leaking single-shell tanks." At least four documented UPRs have occurred within the perimeter fence of the TY Tank Farm: • UPR-200-W-150 occurred in 1973 and was associated with tank TY-103. Overflow of the 241-TX diversion box flowed back into tank TY-103, depositing 3.3 cm (1.3 in.) of sludge waste. No significant activity increases were observed in the tank TY-103 monitoring boreholes. This release has been referred to as a "flooding event" (BHI 1995d); however, there are no details documented that describe the extent of the release (Kos 1997, WIDS). • UPR-200-W-151 occurred in 1974 and was associated with tank TY-104. Leakage of approximately 1,400 gal of supernatant from this tank was identified by a liquid-level decrease of 0.76 cm (0.3 in.) (BHI 1995d). Remaining liquids in the tank were removed using salt well pumping (Kos 1997, WIDS). • UPR-200-W-152 occurred in 1960 and was associated with tank TY-105. Tank TY-105 was designated a confirmed leaker as a result of this release. A salt well was installed to remove liquids from the tank via salt well pumping (Kos 1997, WIDS). • UPR-200-W-153 occurred in 1959 and was associated with tank TY-106. Tank TY-106 was designated a confirmed leaker of unknown quantity of tributyl phosphate (TBP) waste as a result of this release. The intensity of radiation in monitoring borehole 52-06-05 increased, then stabilized. Diatomaceous earth was added to the tank to stabilize the liquid waste (Kos 1997, WIDS).
T and TX/TY Waste Management Areas Regulatory Deficiencies, letter from B. Wilson (Ecology) to K. Klein (RL) and H. Boston (ORP), dated April 18, 2002 (Wilson 2002)	This letter reported that aquifer properties (i.e., flow direction, flow rates, etc.) are fundamental requirements for RCRA groundwater monitoring systems. Furthermore, the nature and extent of contamination at these TSD units have neither been empirically defined nor confirmed by adequate groundwater monitoring data. Also, site-specific dispersivity has not been adequately factored into groundwater modeling to provide a sound basis for point-of-compliance well locations and spacing.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
T Plant Source Aggregate Area Management Study Report, DOE/RL-91-61, Rev. 0 (DOE-RL 1992b)	This report presents the results of an aggregate area management study for the T Plant aggregate area in the 200 Areas of the Hanford Site. This scoping-level study provides the basis for initiating RI/FS activities under CERCLA or RFI/CMS activities under RCRA. The report also integrates select RCRA TSD closure activities with CERCLA and RCRA past-practice investigations. The Hanford Site past-practice strategy focuses on reaching early decisions to initiate and complete cleanup projects, maximizing the use of existing data, coupled with focused short-timeframe investigations where necessary. The strategy includes three paths for interim decision making and a final remedy selection process for the OU that incorporates the three paths and integrates sites not addressed in those paths. The three paths for interim decisions making include the ERA, IRM, and LFI paths. The strategy requires that AAMSRs be prepared to provide an evaluation of existing site data to support initial path decisions. This AAMSR is one of 10 reports that will be prepared for each of the 10 aggregate areas defined in the 200 Areas. The T Plant aggregate area contains a variety of waste disposal and storage units in addition to its plutonium finishing and recovery facilities and support facilities. Historically, high-level wastes were discharged to the soil column through cribs, trenches, and other facilities. Low-level wastes (e.g., cooling and condensate water) were allowed to percolate into the ground through drains and open ditches. Based on construction, purpose, or origin, the T Plant aggregate area WMUs fall into one of the 10 aggregate area subgroups. As a result of the data evaluation process, no WMUs were recommended for ERAs, 33 WMUs were recommended for LFIs (which could lead to IRMs), and 36 WMUs were recommended for final remedy selection. The document also provided insight into the various sources and COPCs applicable to the OU.
TX Tank Farm Vadose Characterization Boring Request, letter from J. Hedges (Ecology) to R. Yasek (ORP), dated March 4, 2002 (Hedges 2002)	In this letter, Ecology requested that ORP consider extending the vadose zone borehole of the eastern side of TX Tank Farm to the groundwater. The basis for this request included the results from the vadose boring at S-SX Tank Farm that was completed as groundwater monitoring well 299-W23-19 and currently represents the point of the highest technetium-99 groundwater concentration measured at the Hanford Site.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary
Waste Site Groupings for 200 Areas Soil Investigations, DOE/RL-96-81, Rev. 0 (DOE-RL 1997)	The analogous site approach concept was a key element in the development of the *200 Areas Soil Remediation Strategy – Environmental Restoration Program* (DOE-RL 1996a) because many of the 200 Area waste sites share similarities in geological conditions, functions, and types of waste received. As a result, the need to establish waste site groups for 200 Area waste sites was identified as an initial step in the implementation of the 200 Areas soil remediation strategy (DOE-RL 1996a). The purpose of this document was to identify logical waste site groups for characterization based on criteria established in 200 Areas soil remediation strategy. Specific objectives of the document included the following; • Finalize waste site groups based on the approach and preliminary groupings identified in the 200 Areas soil remediation strategy. • Prioritize the waste site groups based on criteria developed in the 200 Areas soil remediation strategy. • Select representative sites that best represent typical and worst-case condition for each waste group. • Develop conceptual models for each waste group. Waste site group prioritization and representative site selection will support a more efficient and cost-effective approach to characterizing the 200 Area waste sites. Characterization efforts will be limited to representative sites, the data from which will be used to remedial action decisions for all waste sites within a group (consistent with the analogous site approach). Waste site group properties will be used to establish a sequence in which the representative sites are expected to be addressed. The conceptual models developed in this document provide an initial prediction of the nature and extent of primary COC and support the selection of representative sites and prioritization of groups.
Z Plant Source Aggregate Area Management Study Report, DOE/RL-91-58, Rev. 0 (DOE-RL 1992c)	This report presents the results of an aggregate area management study for the Z Plant aggregate area in the 200 Areas of the Hanford Site. This scoping-level study provides the basis for initiating RI/FS activities under CERCLA or RFI/CMS activities under RCRA. The report also integrates select RCRA TSD closure activities with CERCLA and RCRA past-practice investigations. The Hanford Site past-practice strategy focuses on reaching early decisions to initiate and complete cleanup projects, maximizing the use of existing data, coupled with focused short-timeframe investigations where necessary. The strategy includes three paths for interim decision making and a final remedy selection process for the OU that incorporates the three paths and integrates sites not addressed in those paths. The three paths for interim decisions making include the ERA, IRM, and LFI paths. The strategy requires that AAMSRs be prepared to provide an evaluation of existing site data to support initial path decisions. This AAMSR is one of 10 reports that will be prepared for each of the 10 aggregate areas defined in the 200 Areas The Z Plant aggregate area contains a variety of waste disposal and storage units in addition to its plutonium finishing and recovery facilities and support facilities. Historically, high-level wastes were discharged to the soil column through cribs, trenches, and other facilities. Low-level wastes (e.g., cooling and condensate water) were allowed to percolate into the ground through drains and open ditches. Based on construction, purpose, or origin, the Z Plant aggregate area WMUs fall into one of the 10 aggregate area subgroups. As a result of the data evaluation process, 5 WMUs were recommended for ERAs, no WMUs were recommended for IRMs, 32 WMUs were recommended for LFIs (which could lead to IRMs), and 18 WMUs were recommended for final remedy selection. The document also provided insight into the various sources and COPCs applicable to the OU.
Hanford Virtual Library	This database was used to identify historical data and levels of COPCs measured in groundwater from particular wells.

Table 3-1. 200-ZP-1 Existing References. (13 sheets)

Reference	Summary

AAMSR = aggregate area management study report
AEA = *Atomic Energy Act of 1954*
ALARA = as low as reasonably achievable
ARAR = applicable or relevant and appropriate requirement
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR = *Code of Federal Regulations*
COC = contaminant of concern
COPC = contaminant of potential concern
DOE = U.S. Department of Energy
DQO = data quality objective
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
ERA = expedited response action
FY = fiscal year
GAC = granular activated carbon
gpm = gallons per minute
IRM = interim remedial measure
LFI = limited field investigation
ORP = U.S. Department of Energy, Office of River Protection
OU = operable unit
PFP = Plutonium Finishing Plan
ppm = parts per million
RAO = remedial action objective
RCRA = *Resource Conservation and Recovery Act of 1976*
RI/FS = remedial investigation/feasibility study
ROD = Record of Decision
RFI/CMS = remedial field investigation/corrective measures study
SAC = System Assessment Capability
SAP = sampling and analysis plan
SARA = *Superfund Amendments and Reauthorization Act of 1986*
TCE = trichloroethylene
Tri-Party Agreement = *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 2003)
TSD = treatment, storage, and disposal
UPR = unplanned release
WIDS = Waste Information Data System
WMU = waste management unit

The following sections summarize selected relevant documents that are applicable to this work plan.

3.2 200 WEST GROUNDWATER AGGREGATE AREA MANAGEMENT STUDY

The 200 West groundwater AAMSR (DOE-RL 1993) summarizes information about groundwater contaminants beneath the 200 West Area and provides recommendations for prioritizing, investigating, and remediating various contaminants and plumes. The document provides a detailed description of radiological and nonradiological contaminant plumes in the 200-ZP-1 OU. Radiological plumes included iodine-129, technetium-99, plutonium-239, tritium, and uranium. Nonradiological plumes included arsenic, chromium, fluoride, nitrate, carbon tetrachloride, chloroform, and TCE. In the past, the plumes have migrated radially from several groundwater mounds in the 200-ZP-1 OU. As the liquid discharges have ceased, the groundwater (and entrained plumes) has reverted to a general eastward flow. The average, maximum, and minimum concentrations found in for each of the constituents of these plumes are reported in the AAMSR. The 200 West groundwater AAMSR recommends that the carbon tetrachloride plume be addressed under an expedited response action (ERA). The carbon tetrachloride plume also overlaps plumes of arsenic, fluoride, chloroform, TCE, and plutonium-239/240 that were proposed for other remediation paths. The groundwater AAMSR recommends that the chloroform and TCE plumes should be addressed by the proposed ERA. The maximum reported concentration of carbon tetrachloride in the 200-ZP-1 OU was 8,700 parts per million (ppm). The maximum chloroform and TCE levels were 1,650 ppm and 41 ppm, respectively.

3.3 HYDROLOGIC CONCEPTUAL MODEL FOR THE CARBON TETRACHLORIDE AND URANIUM/TECHNETIUM PLUMES IN THE 200 WEST AREA (1994 THROUGH 1999 UPDATE)

The *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/Technetium Plumes in the 200 West Area: 1994 Through 1999 Update* (BHI 1999b) provides an update for the hydrogeological conceptual model for the carbon tetrachloride and uranium/technetium plumes in the 200 West Area. The document covers the 5-year period from 1994 through 1999 and reports on the progress of various remedial actions undertaken and data gathered during that period. The document summarizes the geological and hydrogeological conceptual model for carbon tetrachloride plume and also includes a summary of analytical results for carbon tetrachloride sampling (through 1999) at depths greater than 10 m (32.8 ft) below the water table.

The document also provides a number of recommendations applicable to the carbon tetrachloride plume in the 200-ZP-1 OU that may be useful in the RI/FS process for 200-ZP-1 groundwater:

- Characterize the deep distribution of carbon tetrachloride in groundwater by advancing new well installations to the uppermost confined aquifer and sample for carbon tetrachloride.
- Install new groundwater wells to monitor deep within the unconfined aquifer.
- Conduct laboratory tests and analysis on representative Hanford Site sediments (to refine estimates of the soil/water organic distribution coefficients (K_ds).

- Conduct a systematic study of the carbon tetrachloride/chloroform relationship in the groundwater using existing data.

3.4 ASSESSMENT OF CARBON TETRACHLORIDE GROUNDWATER TRANSPORT IN SUPPORT OF THE HANFORD CARBON TETRACHLORIDE INNOVATIVE TREATMENT AND REMEDIATION DEMONSTRATION

An assessment of carbon tetrachloride groundwater transport was recently completed by the Innovative Treatment and Remediation Demonstration (ITRD) Program (Truex et al. 2001). Beginning in January 1999, the Technical Advisory Group (TAG) of the Hanford Carbon Tetrachloride ITRD Program began a series of discussions regarding the potential application of remediation technologies at the carbon tetrachloride site in the 200 West Area. The remediation technologies discussed included those for both the saturated zone and the unsaturated zone; however, during the discussions it became evident that the selection of remediation technologies needs to be based on the type of remediation (e.g., source removal from the saturated zone) and the extent to which the remediation needs to occur (i.e., the level to which the carbon tetrachloride concentration must be reduced). To provide this information, the ITRD TAG determined that groundwater modeling (and site characterization) needs to be performed.

The following overall approach was used to examine the transport of carbon tetrachloride from the source area to the compliance boundary as a function of variation in carbon tetrachloride source concentration and transport parameter values. A one-dimensional model was configured to estimate carbon tetrachloride transport.

Ranges for the value of transport parameters within the model (e.g., porosity and K_d) were determined from available literature and Hanford Site data. The uncertainty in the concentration of carbon tetrachloride in the source area was estimated based on geostatistical analysis of existing carbon tetrachloride concentration data at the Hanford Site. The parameter value ranges and source-area carbon tetrachloride concentration variability were used within a Monte Carlo approach, where 1,000 combinations of parameter values and carbon tetrachloride concentration were simulated for selected cases of remaining source area inventory. Each transport simulation provided an estimate of the carbon tetrachloride concentration at the compliance boundary over time. These estimated values were compared to the concentration limit selected by the regulators for the compliance boundary to determine source cleanup requirements for each simulation. The entire set of simulations was used to determine the model parameters that had the greatest influence on the source cleanup requirements.

The modeling was based on the assumption that approximately 750,000 kg of carbon tetrachloride were discharged to the soil in the Z Crib area. Previous work (Rohay 1993, Truex et al. 2001) has shown that of this 750,000 kg, approximately 65% cannot be accounted for; therefore, modeling was performed using 65%, 30%, 10%, and 1% of the 750,000 kg as possible amounts of carbon tetrachloride that could reach the groundwater. It is of value to note that approximately 1% to 2% of the carbon tetrachloride inventory currently exists in the distal plume based on averaged carbon tetrachloride groundwater measurements. Several conclusions drawn from the modeling are as follows:

- If 1% of the discharged carbon tetrachloride is all that ever reaches the groundwater, it is likely that the highest concentration of carbon tetrachloride to arrive at the compliance boundary will not exceed the compliance concentration. However, it is possible that the compliance concentration would be exceeded if the actual site parameters correspond to the lower porosity, lower K_d, and lower abiotic hydrolysis degradation (K_a) values used in this study.
- If 10% or more of the discharged carbon tetrachloride reaches the groundwater, it is likely that the concentration of carbon tetrachloride eventually arriving at the compliance boundary will exceed the compliance concentration (unless source removal efforts are used).
- There is a breakpoint between 1% and 10% of the discharged inventory that defines the amount of carbon tetrachloride in the source at which source removal would be required to avoid exceeding the compliance concentration at the compliance boundary.
- Because the source inventory remaining appears to be the quantity driving the amount of site cleanup required for compliance, source inventory characterization using partitioning interwell tracer tests (or other source-quantity characterization technologies) would be a milestone on the path toward resolution of compliance issues.
- Laboratory experiments and site surveys can be used to better quantify values for the parameters controlling compliance boundary concentrations: K_d, K_a, and porosity. Additional modeling, including use of a three-dimensional model[1], can then be performed using these improved values to provide more accurate estimates of compliance boundary concentrations and source cleanup requirements.

3.5 SAMPLING AND ANALYSIS PLAN FOR THE 200-ZP-1 GROUNDWATER MONITORING WELL NETWORK

Because of the pump-and-treat operations and the general decrease in groundwater elevation due to elimination of effluent release from facilities, the shape of the contaminant plumes in the 200-ZP-1 Groundwater OU has changed. The *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE-RL 2002) was developed to better characterize the status of the plumes, including a reassessment of the wells to sample, COCs, and analytical methods. This previous SAP (DOE-RL 2002) is a precursor to the current SAP, which is provided in Appendix A of this work plan.

The monitoring well SAP (DOE-RL 2002) presented a list of wells similar to those included in the SAP in Appendix A of this work plan. The COCs listed in the 200 Area groundwater monitoring SAP (DOE-RL 2002) included carbon tetrachloride, chloroform, TCE, total chromium, arsenic, cadmium, chromium (total), iodine-129, technetium-99, uranium, tritium, nitrate, and fluoride.

[1] Three-dimensional modeling using K_d and K_a values from the literature is presented in *Hanford Site Groundwater Monitoring for Fiscal Year 2001* (PNNL 2002b).

3.6 DATA QUALITY OBJECTIVE SUMMARY REPORT FOR ESTABLISHING A RCRA/CERCLA/AEA INTEGRATED 200 WEST AND 200 EAST GROUNDWATER MONITORING NETWORK

The purpose of a DQO process conducted in 2002 and 2003 (FH 2003a) was to assess the groundwater monitoring well networks for the 200 West and 200 East Areas and develop an integrated groundwater monitoring network. This assessment is needed to address changing contaminant plume conditions (e.g., plume migration) and to ensure that monitoring activities meet the requirements for remediation performance monitoring (i.e., CERCLA monitoring), Sitewide surveillance monitoring to meet the requirements of DOE orders, and detection/ assessment monitoring to meet RCRA requirements in accordance with 40 *Code of Federal Regulations* (CFR) 264.99. The DQO summary report was prepared in support of DOE's Cleanup, Constraints, Challenges Team process.

Because of the changing shape of the groundwater contaminant plume contours over time and changing programmatic needs, the 200 West and 200 East groundwater monitoring network is required to be periodically re-evaluated. The objective of the groundwater CERCLA remediation performance monitoring program (in accordance with 40 CFR 300.420) is to provide a routine assessment of the effectiveness of groundwater remediation activities within the 200-ZP-1 and 200-UP-1 OUs. The objectives of the Sitewide surveillance monitoring program are as follows:

- Determine baseline conditions of groundwater quality and quantity
- Characterize and define hydrogeologic, physical, and chemical trends in the groundwater system
- Identify existing and potential groundwater contamination sources
- Assess existing and emerging groundwater quality problems
- Evaluate existing and potential offsite impacts of groundwater contamination
- Provide data on which decisions can be made concerning land disposal practices and the management and protection of groundwater resources.

The objective of the RCRA detection program (40 CFR 264.99) is to identify if TSD units are impacting groundwater quality. If impacts to groundwater are detected, the objective of the RCRA assessment program is to define the rate and extent of contaminant migration. The DQO process identified the optimum number of groundwater wells to be monitored to meet these objectives and determined if any new groundwater wells needed to be installed, the sampling frequency, the analyses to be performed, the detection limit requirements, and other analytical performance requirements (e.g., precision and accuracy).

The list of wells resulting from the geostatistical modeling was further refined using hydrogeologic expertise and by considering the goals of the groundwater remediation performance and Sitewide surveillance monitoring programs. The geostatistical modeling used to determine the initial well list is documented in *Data Quality Objectives Summary Report for Establishing 200-ZP-1 and 200-UP-1 Groundwater Monitoring Well Network* (BHI 2002b). The initial list was to determine wells to sample for COCs that had not previously been analyzed. During the subsequent DQO process, as documented in *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process*

(FH 2003b), well locations were refined by considering factors such as water levels in the wells, location of the wells relative to plumes, and potential movement of plumes.

The geostatistical monitoring network was then evaluated to determine if it provided adequate spacing between groundwater monitoring wells, allowing for comprehensive monitoring for all of the contaminant plumes present in the 200-ZP-1 and 200-UP-1 OUs. The monitoring network was also evaluated to determine if any monitoring wells could be removed from the network without negatively impacting the ability of the geostatistical model to predict the boundaries of the contaminant plumes. The results from the geostatistical modeling and non-statistical evaluation concluded that the optimum number of groundwater wells to be monitored within the 200-ZP-1 OU was 62 wells. This was more recently increased to 70 wells in the 200-ZP-1 RI/FS DQO summary report (FH 2003b) as additional data needs were identified based on changes in plume conditions.

The selection of high-priority COCs, the proposed analyses to be performed on samples collected from individual wells, and the frequency at which samples should be collected for analytical testing were also provided for the consolidated monitoring well network. The selected frequency proposed for sampling the wells was dependent upon how many times a well had been sampled in the past. New wells are to be sampled quarterly the first year after installation, semi-annually the second year after installation, then annually from that point on. Biennial sampling is used for perimeter wells that have shown stable concentrations for several years. If irregular or increasing trends appear, the sampling frequency may increase accordingly.

3.7 HISTORICAL SUMMARY

The shapes and concentrations of the COC plumes within the 200-ZP-1 OU have changed over time (DOE-RL 2002) as result of the following:

- Pump-and-treat operations
- Natural groundwater flow
- Source term variability
- Decline in groundwater levels
- Discharge of other waste streams (e.g., cooling water)
- Natural attenuation.

A published evaluation of all of the historical data collected over time for a given COC in the wells of interest has not been fully evaluated since the 200 Area groundwater AAMSR (DOE-RL 1993). As part of this work plan, the COCs identified in the new SAP (Appendix A of this work plan) must be based on a detailed examination of the COCs in the wells of interest over time, through the present. In addition, the changes in groundwater plumes and levels have affected the monitoring wells used to evaluate contaminant plumes and migration. Additional information is required to more adequately address the nature of the groundwater flow regime and to support more accurate modeling of plume migration.

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4.0 WORK PLAN RATIONALE

As a result of pump-and-treat operations, groundwater flow direction, source-term variability, and a decrease in the discharge of other waste streams (e.g., cooling water), the shape and concentration of the COC plumes within the 200-ZP-1 OU have changed over time. This section identifies the basis for additional data needs to support characterization of groundwater for the 200-ZP-1 OU. These characterization needs have been defined largely through the DQO process conducted in support of the RI/FS process for the 200-ZP-1 Groundwater OU (FH 2003b).

Previous documents have focused on the most critical risk drivers and not the COCs posing less risk. This work plan supports the final remedy selection; thus, it must focus on all applicable COCs and use this information to select the final remedial alternative(s) for the 200-ZP-1 Groundwater OU.

4.1 CONTAMINANTS OF CONCERN AND WELL SELECTION

Recent well monitoring data need to be further evaluated based on the data contained in the Hanford Environmental Information System (HEIS) database. The additional data evaluation needs are based on the following concerns:

- There is no limited field investigation for 200-ZP-1 OU groundwater, and several COCs have been deferred until the final RI/FS, which is the subject of this work plan.
- Historical data have been obtained with detection or reporting limits above the corresponding regulatory limit. As a result, an assessment is desirable as to whether lower reporting limits are needed and can be achieved for some COCs.
- For some wells and/or COCs, data have not been obtained for several years. As a result, data are needed (40 CFR 264.99, 40 CFR 300.420) to verify that movement from the vadose zone to the groundwater has not occurred.
- Several wells are dry, or nearly dry; thus, replacement wells need to be selected.

Appendix C of this work plan provides the results of the data evaluation.

4.2 SATURATED ZONE PROPERTIES FOR MODELING INPUT

In addition to data that characterize specific aspects of groundwater COC contamination and gradient, information is needed to support groundwater modeling in the saturated zone. Saturated zone properties (e.g., hydraulic transfer, physical/geological, and geochemical makeup) are needed to provide input to the groundwater transport models.

This work plan and SAP (Appendix A), supported by the RI/FS DQO summary report (FH 2003b), provide the logic for obtaining the above information.

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5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

Section 3.0 provides a summary of the previous investigations that have been performed to characterize various aspects or to address specific concerns of the 200-ZP-1 OU. As described in Section 4.0, the information generated from previous studies indicates a need for additional data collection in order to support final remedial action. This section describes the activities that will be performed as part of the RI/FS to obtain the data required to support the selection of remedial action alternative(s) for the 200-ZP-1 Groundwater OU. Section 5.1 focuses on expansion of the groundwater monitoring well network, describes the routine groundwater monitoring strategy, addresses the groundwater testing for COCs that are known to be present in the vadose zone, and addresses data needed to support risk modeling and defining the three-dimensional distribution of COCs. Sections 5.2 through 5.5 discuss the tasks that use the data gathered as discussed in Section 5.1.

Data-gathering efforts described in this section are to be taken as appropriate CERCLA data collection measures to develop additional data as required by 40 CFR 300.420 pursuant to remedial site evaluations.

5.1 REMEDIAL INVESTIGATION

5.1.1 Enhanced Groundwater Monitoring Well Network

Of the 71 wells identified for monitoring in Table A3-2 (Appendix A), 63 wells currently exist and eight are new wells to be installed. As shown in the plate map presented in Appendix B, the 63 existing wells are relatively evenly distributed within the boundaries of the COC plumes, with a tighter concentration of wells around the 2,000 μg/L carbon tetrachloride contour. The eight new wells (identified by a letter) are positioned at locations identified as data gaps (FH 2003a, 2003b). New wells "C," "D," "E," and "F" are proposed to be installed to refine the perimeter of the 2,000 μg/L carbon tetrachloride contour. New well "G" is proposed to be installed to refine the eastern portion of the 5 μg/L carbon tetrachloride contour. New well "H" is proposed to be installed west of T Plant to help define the vertical spreading of the TCE, nitrate, tritium, uranium, and iodine plumes in that region of the site, as well as to provide additional vertical distribution data (i.e., physical, geological, hydraulic, chemical, and geochemical properties) for this region of the OU. New well "I" is proposed to be installed as an upgradient monitoring well for the 200-ZP-1 OU. New well "T" is proposed to be installed due north of T Plant to define the northern edge of the nitrate, carbon tetrachloride, and tritium plume. Table 5-1 presents the proposed priority in which the new 200-ZP-1 wells are currently planned to be installed.

To assist in defining the three-dimensional distribution of COCs within the unconfined aquifer, approximately five depth-discrete groundwater and soil samples collected from new wells "C," "H," and 299-W15-46 (described in Appendix A, Section A1.3.5) shall be tested using the analytical methods described in Table 5-2 and Tables A2-1 and A2-2 (Appendix A). New wells "C" and "H" will be drilled to the top of the Ringold Lower Mud Unit, approximately 36.6 to 61 m [120 to 200 ft] below the top of the unconfined aquifer; new well 299-W15-46 will be drilled through the Ringold Lower Mud Unit to basalt.

Table 5-1. Priority for New Well Installation in the 200-ZP-1 Operable Unit.

Priority	New Well Name
1 (highest)	C
2	D
3	E
4	F
5	G
6	H
7	I
8 (lowest)	T

In addition, wells "D," "E," "F," "G," "I," and "T" (shown in Appendix B) will be drilled 36.6 m (120 ft) below the water table and a series of depth-discrete groundwater samples will be collected beyond the samples indicated in Table A3-2 (Appendix A). These depth-discrete samples will be collected at approximately 9.1-m (30-ft) intervals, for a total of four samples. These samples shall be analyzed for carbon tetrachloride, TCE, chloroform, and tetrachloroethylene (PCE). These four COCs have been selected as indicator COCs that will provide insight into the three-dimensional distribution of contaminants within the aquifer.

All wells will be installed with 4-in. inside-diameter, stainless-steel screens and riser pipe. The screens will be approximately 9.15 m (30 ft), and the slot size will be based on the grain-size analysis. Wells will be screened at the interval with the highest concentration of COCs. The well completion depth will vary, but the average completion depth is expected to be approximately 88.45 m (290 ft).

5.1.2 Routine Groundwater Monitoring Strategy

Newly installed wells and replacement wells are to be sampled quarterly the first year after installation, semi-annually the second year after installation, and annually from that point on. Perimeter wells that have shown stable concentrations for several years will be sampled biennially (every 2 years). Conversely, if a well begins to show stable concentrations, the sampling frequency may decrease. If irregular or increasing trends appear, the sampling frequency may increase. Table A3-2 in the SAP (Appendix A) lists the existing and proposed wells in the 200-ZP-1 OU monitoring well network, presents the sample analyses for individual wells, and indicates the frequency at which samples will be collected.

If future characterization activities identify areas of high contaminant concentration (i.e., above the 2,000 to 3,000 parts per billion [ppb] action level for carbon tetrachloride specified in the interim ROD), then RL and EPA shall discuss expansion of the treatment system.

Table 5-2. Model Input Parameter Sampling and Analysis Requirements for New Groundwater Wells at the 200-ZP-1 Operable Unit.

New Well Name	Physical/Geological Properties (from Table A-2)	Hydraulic Properties (from Table A-2)	Geochemical Properties (from Table A-2)	K_d Specific COCs	Deep Well	Rationale for Selecting Well	Sampling Frequency
C[a]	X	X	X	X	X	This location could help determine the source of carbon tetrachloride contamination recently detected upgradient of the TX-TY Tank Farm. It is located downgradient of burial ground LLWMA 4. In addition, well "C" is located within a nitrate plume.	Initially when the well is installed
299-W15-46[b]	X	X	X	X	X	This location has historically shown some of the highest concentrations of carbon tetrachloride with depth within the aquifer. In addition, it is within several other plumes, including chloroform, nitrate, and trichloroethylene.	Initially when the well is installed
H[a]	X	X	X	X	X	This location is to the west of T Plant and is inside or adjacent to several groundwater plumes including I-129, nitrate, trichloroethylene, tritium, and uranium. Depth-discrete groundwater samples from this location will help verify the depth interval where contaminants are concentrated.	Initially when the well is installed

[a] Wells "C" and "H" will be drilled to the top of the Ringold Lower Mud Unit.
[b] Well will be drilled in 2003/2004 near the Z-9 Crib. The well name is provisional and may change when the well is drilled. Well 299-W15-46 will be drilled to basalt.
COC = contaminant of concern
K_d = distribution coefficient
LLWMA = Low-Level Waste Management Area

5.1.3 Monitoring for Additional Contaminants of Concern

During preparation of the 200-ZP-1 DQO summary report (FH 2003b), a number of historical documents were researched for the purpose of identifying a comprehensive list of contaminants of potential concern (COPCs) that should be taken into consideration when going through the CERCLA RI/FS process. A number of these COPCs were able to be eliminated after reviewing historical analytical data, radioactive half-life, soil adsorption, and toxicity. Those COPCs that were retained became the COCs that are undergoing evaluation in this work plan. Appendix D of the DQO summary report (FH 2003b) contains a list of all COPCs and the rationale for their inclusion or exclusion as COCs.

The implementation strategy to obtain information regarding these additional COCs is to sample specific wells in high-concentration areas of the plumes and/or at wells immediately downgradient from selected waste sites. Two rounds of sampling are scheduled: the first in FY04, and the second in FY06. The results of the two initial sampling and analysis events will be evaluated and, if one or more of these additional COCs are detected above the target action levels as specified in Table A1-7 (Appendix A), the supporting SAP will be updated to add these COCs to the routine sampling program. If the additional COCs are not detected above these levels during the first two sampling events, they will not be considered further in the RI/FS process. Table A3-3 in the SAP (Appendix A) presents the wells that have been chosen for this additional sampling. These wells will be analyzed for the COCs listed in Table A2-1 (Appendix A) according to the listed methods.

5.1.4 Modeling Input Parameters

Specific modeling input parameters have been identified as being needed to support modeling of carbon tetrachloride and a variety of other contaminant plumes within the 200-ZP-1 OU. Modeling input parameters (e.g., K_d, hydraulic conductivity, particle size, and cation exchange capacity) are needed to adequately model potential contaminant movement in the saturated zone. The saturated zone sediments in the 200-ZP-1 OU have been extensively characterized in the past, and this historical data will be used to support modeling activities. However, the DQO summary report supporting this work plan (FH 2003b) identified the need for additional modeling inputs (see Appendix A, Tables A1-6 and A2-2). These inputs will be collected from the saturated zone of three selected wells (new wells "C," "H," and 299-W15-46) within the 200-ZP-1 OU as they are being installed or will be collected from these selected wells following well installation (e.g., well development and aquifer testing). These three wells were selected based on professional judgment to be representative of the 218-W-4B/218-W-2 Burial Grounds, T Plant, and Z Plant, respectively. The approximate locations for new wells "C," "H," and 299-W15-46 are shown on the plate map in Appendix B. All three of the selected wells are located within multiple contaminant plumes and were selected to fulfill multiple data needs as noted in Table A1-6 (Appendix A). While the initial purpose for selecting new wells "C" and 299-W15-46 was to provide missing data related to the carbon tetrachloride plume, these locations will also be representative of a variety of other contaminants that may be originating from the 218-W-4B/218-W-2 Burial Grounds and Z Plant, respectively. New well "H" is positioned near the center of multiple plumes (including uranium, iodine, tritium, TCE, and nitrate) to assist in characterizing the three dimensional distribution of these contaminants in the vicinity of T Plant. It is anticipated that the data obtained from these wells will supplement existing data and allow modeling of the movement of contaminants in the 200-ZP-1 groundwater that is adequate to support the RI process.

Approximately five depth-discrete groundwater and soil samples shall be collected during drilling of the three identified new wells. These samples shall be approximately evenly spaced between the top of the water table and the top of the Ringold Lower Mud Unit, or about 36.6 to 61.0 m (120 to 200 ft) below the top of the unconfined aquifer. Well 299-W15-46 will be drilled through the Ringold Lower Mud Unit to basalt and an additional groundwater sample shall be collected from this interval. These samples shall be analyzed for the parameters identified in Table A2-2 (Appendix A). These samples shall also be tested for the parameters identified in Table A2-1 (Appendix A), as discussed in Section 5.1.3 of this work plan.

These three new wells will be completed to screen the upper portion of the unconfined aquifer unless the highest concentration of contaminants is found at a deeper interval. In the latter case, RL and EPA will be consulted on the interval to be screened. The data obtained from these wells will allow more accurate modeling of plume movement and knowledge of the vertical distribution of the COCs.

5.1.5 Three-Dimensional Distribution of Contaminants of Concern

To assist in defining the three-dimensional distribution of COCs within the unconfined aquifer, approximately five depth-discrete groundwater and soil samples collected from new wells "C," "H," and 299-W15-46 (described in Section 5.1.4) shall be tested using the analytical methods described in Table A2-1 (Appendix A). Note that these samples shall also be tested for the modeling input parameters described in Table A2-2 (Appendix A).

In addition, wells "D," "E," "F," "G," "I," and "T" (shown in Appendix B) will be drilled 36.6 m (120 ft) below the water table and a series of depth-discrete groundwater samples will be collected beyond the samples indicated in Table A3-2 (Appendix A). These depth-discrete samples will be collected at approximately 9.1-m (30-ft) intervals, for a total of four samples. These samples shall be analyzed for carbon tetrachloride, TCE, chloroform, and PCE. These four COCs have been selected as indicator COCs that will provide insight into the three-dimensional distribution of contaminants within the aquifer.

5.1.6 Aquifer Testing

Detailed hydrologic testing will be conducted at approximately three well locations to provide required input characterization parameters for numerical groundwater models needed to evaluate fate and transport of contaminants. In general, from one to three hydrologic tests will be conducted at each of these well sites. Hydrologic tests that may be performed include the following: slug tests, slug interference tests, constant-rate discharge tests, and tracer tests (e.g., single- or dual-well tests).

Multiple depth intervals may be tested to provide an indication of the vertical distribution of hydraulic properties. For wells that are drilled to the Ringold Lower Mud Unit (Unit 9), as many as three depth intervals will be tested: one near the top of the aquifer, one near an intermediate zone, and one near the bottom of the unconfined aquifer. For wells that are already completed in the upper part of the aquifer, only the upper interval will be tested.

Hydrologic parameters of primary interest include the following: hydraulic conductivity, vertical anisotropy, longitudinal and transverse dispersivity, and effective porosity. Preference in the test characterization will focus on the use of test methods that provide larger-scale hydraulic property values, because this is consistent with the scale currently used by Hanford Site groundwater models. It is recognized that the disposal of purgewater (which may be generated using constant-rate discharge tests) may pose a problem at some well site locations. In these instances, the use of constant-rate discharge testing may be limited; however, high priority will be given for testing the upper test interval in all wells (if possible) using this characterization method. Other hydrologic testing methods can be used for characterizing deeper test intervals within the aquifer.

Prior to developing a final detailed hydrologic test plan that identifies specific hydrologic test methods to be conducted, Fluor Hanford, Inc. will discuss with PNNL the benefits of different test design options, well configurations, and well locations for performing characterization tests to maximize data quality. Data quality, however, may be constrained by existing test/site logistics (e.g., disposal of purgewater, presence or lack of monitoring wells, pump-and-treat operational restrictions, etc.).

5.1.7 Supplemental Data

The data resulting from implementation of this work plan may be supplemented by information derived from other groundwater investigations performed onsite. This supplemental information includes, but is not limited to, the following:

- Performing sampling and analysis activities required to monitor sites under RCRA
- Collecting water level measurements
- Collecting pH, temperature, and conductivity readings
- Performing hydrologic testing; implementing QA activities (e.g., Washington State Department of Health co-sampling)
- Possibly performing research activities.

The supplemental data may be used to help refine the conceptual site model and to provide information on contaminant movement through the vadose zone. Wells potentially providing supplemental information for the 200-ZP-1 network and the purpose for sampling each of these wells are presented in Appendix B of the RI/FS DQO summary report (FH 2003b).

5.1.8 Dense Nonaqueous Phase Liquid Investigations

The presence or absence of DNAPLs in the 200-ZP-1 OU and its three-dimensional distribution within the OU is recognized as a data gap that needs to be filled to support the CERCLA RI/FS process. The DNAPL investigations in the vadose zone and groundwater in the vicinity of the 216-Z-9 Trench are currently being addressed by the *Sampling and Analysis Plan for Investigation of Dense Nonaqueous Phase Liquid Carbon Tetrachloride at the 216-Z-9 Trench* (DOE-RL 2003c). A separate SAP will be prepared to address the remainder of the DNAPL characterization strategy identified in Section 6.5 of *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (DOE-RL 2004). This DNAPL characterization data shall be available to support the CERCLA RI/FS project schedule identified in Figure 6-1 of this work plan. RL is committed to complete DNAPL investigations in the timeframe specified in the project schedule (Figure 6-1) and DOE-RL (2004).

5.1.9 Sampling Design for Microscopic and Geochemical Analysis

A study of the geochemical process involved in the contaminant plume saturated zone requires as many as five, 2- to 5-kg (4.4- to 11.01-lb) aquifer sediment samples obtained from the near source, middle, and distal regions of the contaminated groundwater plume. These samples would be collected during drilling of proposed wells "C," "H," and 299-W15-46 (Table 5-2). The samples will be analyzed for the model input parameters described in Table A2-2 of the attached SAP (Appendix A). As described in Section 5.1.5, these samples will also be tested using the analytical methods described in Table A2-1 (Appendix A).

Using these samples, the following activities may also be performed to better characterize the behavior of transport mechanisms in the groundwater:

- Determination of retardation processes and sorbed/dissolved contaminant inventories in groundwater, and the kinetics of solid-liquid redistribution phenomena controlling migration and influencing potential remediation efficiency.
- A combination of microscopic contaminant characterization with advanced radiochemical, microscopic, and analytical techniques, and kinetic studies of desorption/dissolution rate could provide information necessary to assess the long-term behavior of contaminants in the vadose zone and contaminated groundwater at the 200-ZP-1 OU. The experimental measurements would then be interpreted with a suite of geochemical and mass transport models that are maintained and/or were developed by PNNL.

5.2 REMEDIAL INVESTIGATION REPORT

The RI report provides a summary of all site investigations conducted within the OU. The RI report includes analyses of the ongoing activities, data collection performed as part of interim measures, and data generated as a result of the activities performed as described in this work plan. The data will include not only the analytical results from evaluation of groundwater samples, but also the output from groundwater modeling conducted using the inputs from hydrogeologic data collected as described in this work plan. The RI report will include a summary of the data, which will provide the basis for reaching some conclusions about the nature and extent of contamination within the OU, as well as the potential for future contamination and migration pathways. The RI report will identify any remaining data gaps and will provide the information necessary to conduct a risk assessment for the OU.

5.3 GROUNDWATER MODELS AND RISK ASSESSMENT

In order to calculate cleanup levels and predict contaminant migration rates in the vadose zone and groundwater, an integrated modeling system is required that is capable of predicting the movement of contaminants through the vadose zone to the groundwater, and subsequently on to the Columbia River. Several of the decision statements (DSs) and decision rules (DRs) in Tables A1-3 and A1-4 (Appendix A) require the application of professional judgment regarding the adequacy of current information to predict future movement of the COCs from the vadose zone into the groundwater. These decisions will likely be based on iterations of the System Assessment Capability (SAC) using the Sitewide groundwater model and/or other Hanford Site and area-specific modeling tools (Kincaid et al. 1998, Bryce et al. 2002). Because these models are critical to the RI decision-making process, it is important to reduce the uncertainty in the model predictions as much as possible. The data-gathering effort described in Sections 5.1.1 through 5.1.9 is anticipated to reduce uncertainty in model predictions by using actual field condition input data as opposed to data obtained from literature.

The SAC framework uses accepted models for specific portions of the process of COC movement from waste site, to the vadose zone, to the groundwater. For example, vadose zone transport of COCs to the groundwater is modeled using the Subsurface Transport Over Multiple Phases (STOMP) code; groundwater transport to the river uses the Coupled Fluid, Energy, and Soluble Transport (CFEST) code. Because the SAC is a framework, upgrades and different models could be accommodated in the future to refine the estimates of COC movement in a specific location or media.

Figure 5-1 provides a flow diagram of the various modules that are currently a part of the SAC framework. This work plan will acquire data that can be used to populate model inputs for the Groundwater Module. The information from the Groundwater Module will be used in the Risk/Impact Module. The Vadose Zone Module, which feeds information to the Groundwater Module, will be populated by data generated from the Waste Site Remediation Project and is not part of this work plan.

5.3.1 *Brief Description of the System Assessment Capability Models*

The models and their relationship and contribution to the RI/FS are described in Section 3.0 of the RI/FS DQO summary report (FH 2003b). The following is a brief summary of the models.

The SAC is comprised of various transport models and databases that are linked together so they can provide predictions of the behavior of COCs as they move from the waste sites through the vadose zone, and ultimately to the groundwater and Columbia River. The SAC also assesses the impact of contaminants on human health and the environment. The SAC model predictions are based on a comprehensive inventory of potential contaminants from Hanford operations as far back as 1944. With information about the quantity and concentration of contaminants at a site, in addition to the chemistry of the waste stream, physical/geological, hydrological/transport and geochemical attributes of the site, SAC determines how the contaminant will behave in the soil, air, and groundwater.

The components of the SAC have been organized to simulate the historical and future transport and fate of contaminants from their presence in Hanford waste sites, through their release into the vadose zone, to their movement in the groundwater, and to the Columbia River. The current SAC framework also includes an atmospheric transport module. The conceptual illustration of SAC (Figure 5-2) portrays a linear flow of information. In general, inventory feeds to release to the atmospheric, vadose zone, groundwater, and Columbia River pathways. At times, release occurs directly to the groundwater through reverse wells and to the Columbia River from the single-pass reactors. During chemical separation plant operation, release occurred to the atmosphere. The atmosphere, groundwater, Columbia River, and riparian zone technical elements provide media-specific concentration estimates used in the risk and impact assessments.

Figure 5-1. Modules Within the System Assessment Capability Framework. (2 sheets)

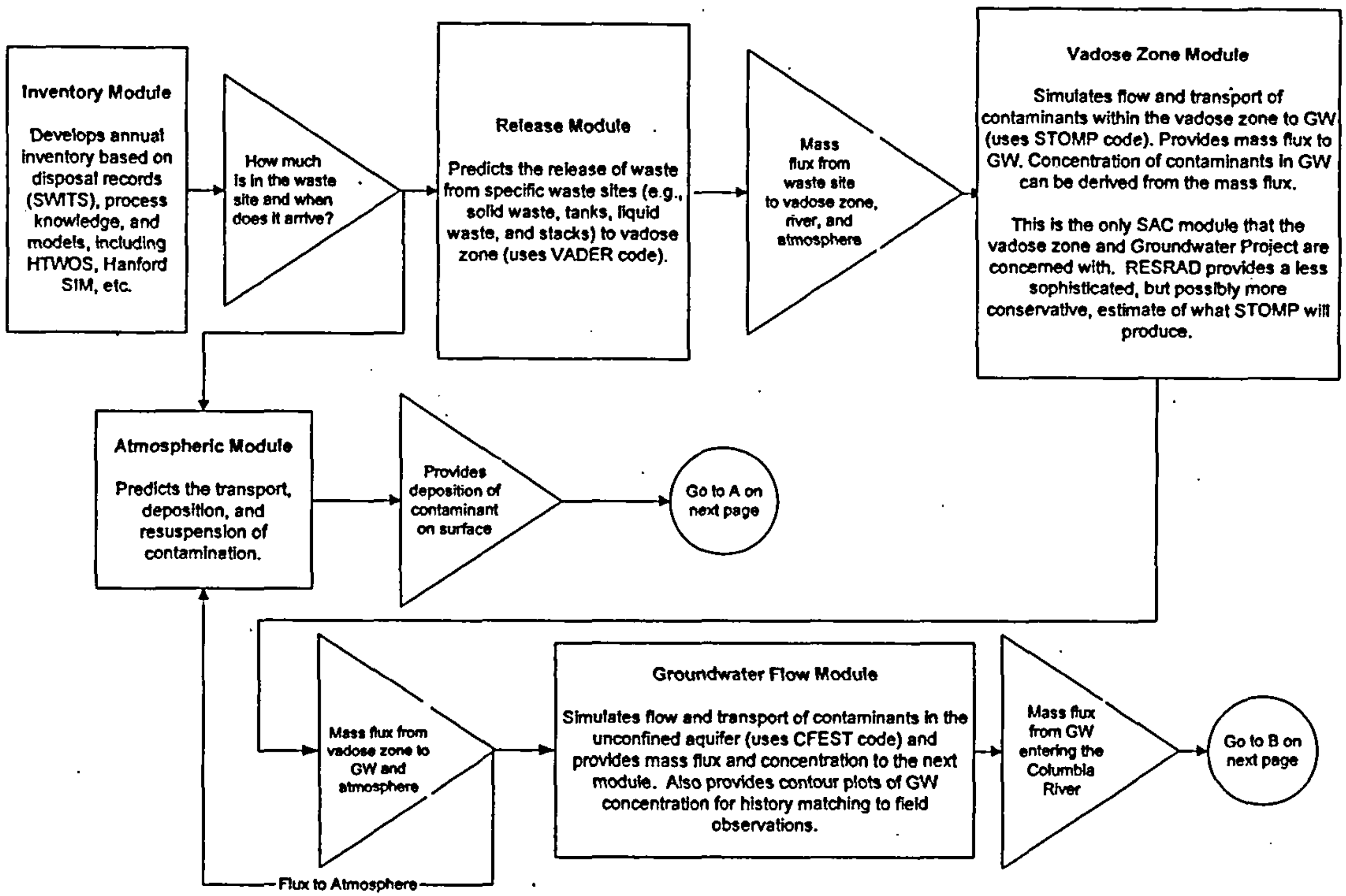


Figure 5-1. Modules Within the System Assessment Capability Framework. (2 sheets)

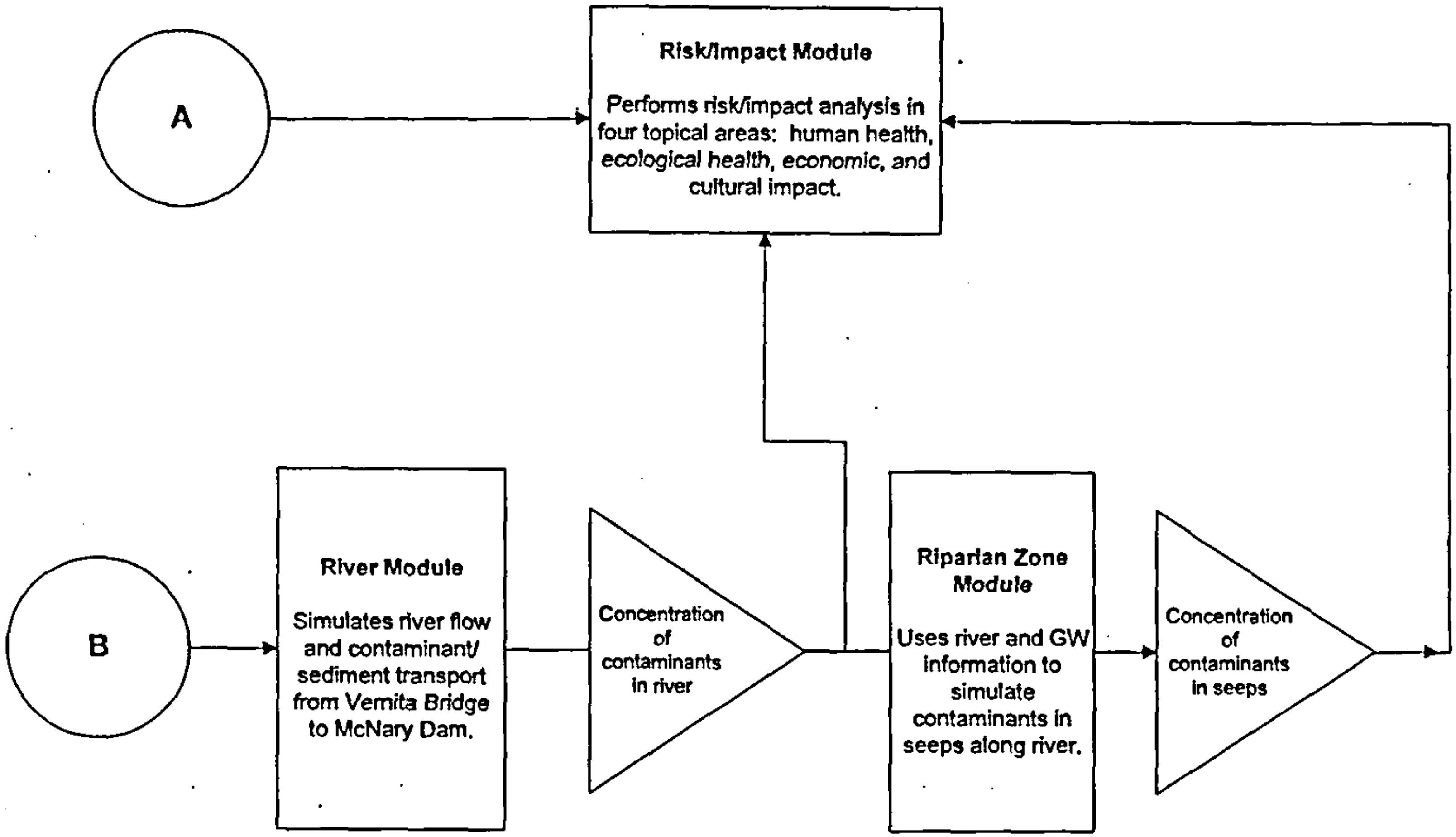
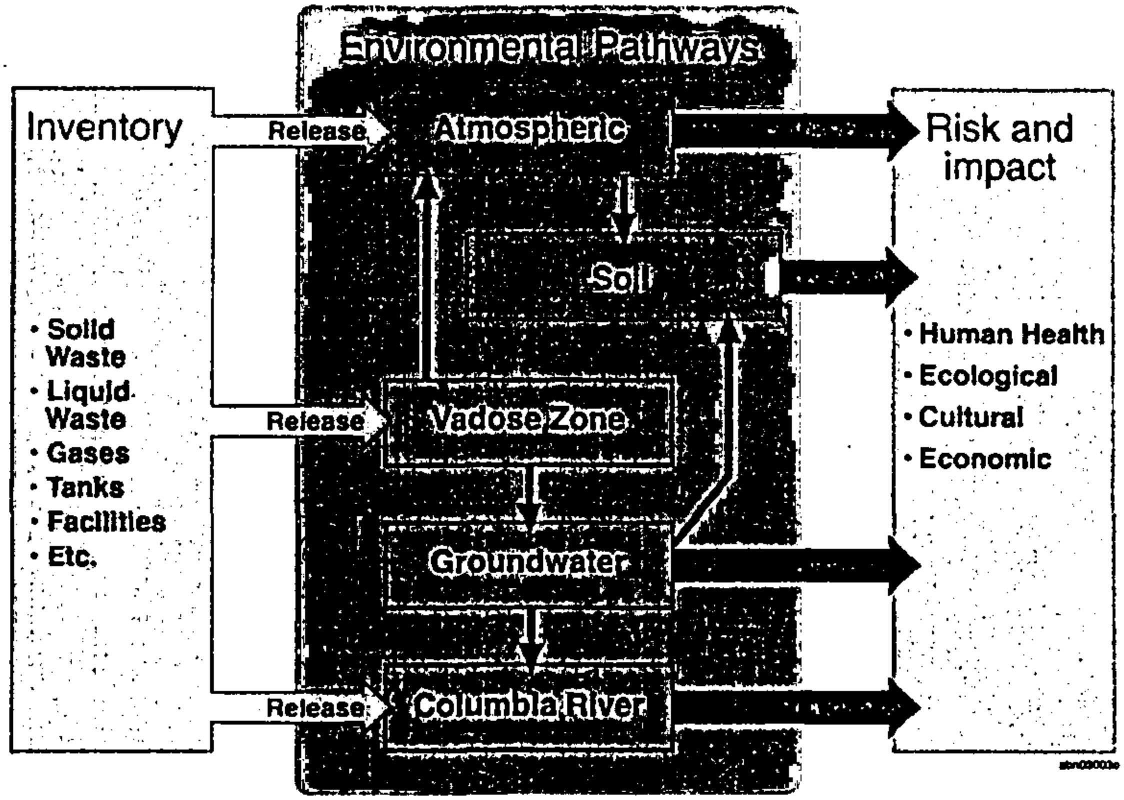


Figure 5-2. Conceptual Model of the System Assessment Capability.



Background information for the development of the initial SAC is presented in *Groundwater/ Vadose Zone Integration Project: Preliminary System Assessment Capability Concepts for Architecture, Platform, and Data Management* (BHI 1999a), which can be found on the Internet at http://www.hanford.gov/cp/gpp/modeling/sacarchive.cfm. The document includes a description of alternate architectures for the SAC, as well as conceptual models for each technical element of the capability. Design of the initial SAC tool is summarized in *Groundwater/Vadose Zone Integration Project: System Assessment Capability) – Assessment Description, Requirements, Software Design, and Test Plan* (BHI 2000). Results of an initial assessment performed with the SAC are provided in Bryce et al. (2002), and a description of the software is provided in Vols. 1 and 2 of *User Instructions for the Systems Assessment Capability, Rev. 0, Computer Codes, Vol. 1: Inventory, Release, and Transport Modules* (PNNL 2002c).

The SAC was developed to allow the performance of a probabilistic risk assessment using a Monte Carlo approach so an indication of the effect of parameter uncertainty on results could be examined. However, an option exists to perform a deterministic simulation. Because of the number of waste sites and contaminants, the computational resources required to perform an analysis, especially a stochastic analysis, are significant. The initial assessment using SAC described in Bryce et al. (2002) was limited to 25 realizations with an objective to gain insight regarding the central tendency and spread the results for the case being analyzed. The initial application of the SAC for use in this RI/FS will likely involve a deterministic analysis using mean or medium parameter values developed from the initial assessment.

Computer codes that provide the basis of specific computational modules with the SAC have been tested at the Hanford Site. The SAC was recently used to perform assessments for cleanup planning efforts, including the *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS)* (DOE 2003), and will be the analysis framework used to perform the 2004 composite analysis of the Hanford Site.

The following is a brief summary of the key component models in the SAC:

- **Inventory Module:** Inventory consists of the quantity of radiological and chemical constituents used and created at the Hanford Site and their distribution in individual facilities and waste disposal sites. Inventory is defined as the volume and concentration of contamination introduced annually to waste disposal sites (e.g., the solid waste burial ground), facilities (e.g., canyon building), and the environment (e.g., vadose zone via liquid discharge sites, Columbia River via reactor cooling water retention basins). In the initial assessment, export to offsite locations is provided by collecting exports at the conclusion of the analysis. The movement of onsite waste from one location to another is included in the Release Module. Finally, tank waste moves into the Inventory Module only after it leaks to the environment or is recovered from tanks and processed into waste forms that are disposed onsite or shipped offsite.

  The information in the Inventory Module includes the following:

  - Location and time of discharges, disposals, and operations
  - Volume of discharge or disposal
  - Concentration (or mass/activity) of contaminants in waste.

  The data for each disposal or release each year were summed to estimate the total inventory disposed or discharged (PNNL 2002a).

- **Release Module:** The Release Module handles liquid releases and releases from solid waste forms. Liquid releases are handled as a simple pass-through to the vadose zone or to the Columbia River. The solid forms are primarily from solid waste burial grounds, including past-practice sites (pre-1988), active sites (post-1988), and the Environmental Restoration Disposal Facility. Other solid waste includes residual waste in the single- and double-shell tanks, naval reactor compartments, immobilized low-activity waste, graphite cores of the retired production reactors, and concrete and cement waste associated with caissons and canyon buildings. The initial assessment (Bryce et al. 2002) included models for most of the releases to provide an estimate of the contaminant release rate, as a function of time, to the vadose environment underlying the material disposal site. Release models for the naval reactor compartments are omitted from the SAC because it is not anticipated that the compartments will release in the 1,000-year period of the initial assessment.

  The Release Module applies release models to waste inventory data from the Inventory Module and accounts for site remediation activities as a function of time. The resulting releases to the vadose zone, expressed as time profiles of annual rates, become source terms for the Vadose Zone Module. Radioactive decay is accounted for in all inputs and outputs of the Release Module.

  The Release Module of the SAC is implemented using the Vadose Zone Release (VADER) code. VADER runs as a stand-alone program within the context of the SAC system. Its purpose is to calculate quantities of waste material released from containment into the environment at the vadose source zone at regular (annual) time steps based on waste release models. A single VADER run performs these calculations for a given analyte at a given release site, using one or more built-in waste release models. The time series of annual releases forms the boundary conditions or source term for subsequent programs to calculate fate and transport of contaminants through the vadose zone to groundwater. A single VADER run generates one set of deterministic waste releases for a given analyte on a given site inventory, using deterministic release model coefficients. Monte Carlo simulations are performed by running VADER many times, each time with a different realization of model coefficients and inventory. This ensemble of time profiles would be examined as a whole to assess the variability in release profiles (PNNL 2002c).

- **Vadose Zone Module:** The Vadose Zone Module of the SAC is focused on evaluating the transport and fate of contaminants as they move through the vadose zone. Thus, the principal geographic focus of this module is on areas at the Hanford Site that (1) underlie liquid waste disposal sites, (2) underlie underground storage tanks or solid waste burial grounds that have the potential for leaks/leaking, and/or (3) have experienced past leaks and spills.

  The initial assessment with SAC (Bryce et al. 2002) simulated intentional and unplanned liquid discharges and solid waste disposal to 890 individual sites but aggregates 200 solid waste burial grounds and unplanned releases into 30 aggregate sites based on their location, waste release model, and waste chemistry designations. These and other aggregations yield a total of 533 sites to be individually simulated. These sites were grouped into 13 different hydrogeologic provinces, each represented by a single generalized, one-dimensional vadose zone profile.

  A series of 64 base templates were identified for application in 13 hydrogeologic provinces. These base templates consist of the one-dimensional stratigraphy, hydrologic properties, and geochemical properties, as well as the waste site type (e.g., crib, tank, etc.) and waste chemistry designation. Each individual template was configured with the hydraulic and geochemical parameters necessary for the STOMP code to simulate flow and transport through the vadose zone. The hydraulic and geochemical input parameter described in this report were updated/revised prior to running the final version of the assessment.

  The *Groundwater/Vadose Zone Integration Project: System Assessment Capability) – Assessment Description, Requirements, Software Design, and Test Plan* (BHI 2000) identified the STOMP computer code (White and Oostrom 2000) as the computational code for the Vadose Zone Flow and Transport Module for the SAC. In broad terms, the STOMP simulator solves coupled conservation equations for component mass and energy that describe subsurface flow over multiple phases through variably saturated geologic media. The resulting flow fields are used to sequentially solve conservation equations for solute transport with radioactive chain decay over multiple phases through variably saturated geologic media. These conservation equations for component mass, energy, and solute mass are partial differential equations that mathematically describe flow and transport through porous media and are collectively referred to as the "governing equations." The STOMP simulator has capabilities for modeling subsurface flow and transport over three distinct phases: aqueous, gas, and nonaqueous phase liquid (PNNL 2002c).

- **Groundwater Module:** The Groundwater Module of the SAC focuses on groundwater that is part of the uppermost saturated zone on the Hanford Site, commonly referred to as the unconfined aquifer, which offers a pathway for contaminants released through the vadose zone from past, present, and future site activities to reach the accessible environment. Radioactive and hazardous chemicals have been released on the Hanford Site from a variety of sources, including ponds, cribs, ditches, injection wells (referred to as "reverse wells"), surface spills, and tank leaks. Many of these sources have already affected the groundwater, and some may affect it in the future. Once in the groundwater, contaminants move along the pathways of least resistance, from higher to lower elevations, where some contaminants may ultimately discharge into the Columbia River.

  The focus of the Groundwater Module is to elevate the transport of contaminants released from the vadose zone to points of regional discharge of groundwater along the Columbia River within the 1,000-year assessment period. Contaminants released to the groundwater form plumes, some of which extend from their source areas to the Columbia River. The Groundwater Module also calculates the concentrations of contaminants in the groundwater for direct use in impact and risk calculations.

  A complete description of the Sitewide groundwater flow and transport model used in the current SAC framework is provided in *Transient Inverse Calibration of Hanford Operational Impacts – 1943 to 1996* (Cole et al. 2001). The current approach relies on a three-dimensional representation of the aquifer system that was calibrated to Hanford Sitewide groundwater modeling data collected during Hanford operations from 1943 to present. The calibration procedure and results for this model are also described in Cole et al. (2001).

  The current Hanford Sitewide groundwater model is implemented with the CFEST code (Gupta et al. 1987, Cole et al. 1988), which was identified as the code of choice for the Groundwater Flow and Transport Module in the initial assessment (BHI 2000). The CFEST code was originally designed to support the radioactive waste repository investigations under DOE's Civilian Radioactive Waste Management Program (Gupta et al. 1987). The chemical waste management community has also used it for conducting exposure assessments, evaluating remediation alternatives, and designing extraction and control systems for aquifers. CFEST is an approved code for working on Tri-Party Agreement (Ecology et al. 2003) milestones related to risk assessment (DOE 1991).

- **River Transport Module:** The River Transport Module of the SAC simulates the Columbia River between the Vernita Bridge and McNary Dam, including inputs from groundwater, the Yakima River, and the Snake River. The contaminants modeled in the river come from three sources:

  - Those already in the river when water reaches the Vernita Bridge from upstream sources and atmospheric fallout
  - Contaminant influx from Hanford waste sites through groundwater
  - Direct discharge to the river from Hanford facilities.

Groundwater and irrigation return discharges to the river along the shore opposite the Hanford Site are not included in the initial assessment.

The basis of the River Transport Module is provided by the Modular Aquatic Simulation System 2D (MASS2) code. MASS2 is a two-dimensional, depth-averaged, hydrodynamics model that provides the capability to simulate the lateral (bank-to-bank) variation of flow and transport of sediments and contaminants. The model incorporates river hydraulics (i.e., velocity and water depth), contaminant influx to the river through groundwater and point sources, sediment and contaminant transport, and adsorption/desorption of contaminant to sediments (PNNL 2002c).

- **Riparian Zone Module:** The riparian zone is the vegetated corridor of land adjacent to the river where there is significant interaction between groundwater and river water. It is an area of transition between aquatic and upland ecosystems. The purpose of the Riparian Zone Module is to calculate the concentrations in riparian zone seep water and the associated wet soil. The Riparian Zone Module relies on input from the Groundwater and River Modules, which includes the spatial and temporal distribution of contaminant concentrations in the groundwater and surface water. These input data are annual, time-averaged concentrations, so seasonal and daily changes in river stage are not reflected in the seep and riverbank soil concentrations calculated by Riparian Zone Module.

  The Riparian Zone Module is the final environmental module, and it is run only after completion of the Groundwater and River Modules. Following completion of the run(s) for the implementation model, the concentration dataset for the Risk/Impact Module is complete (PNNL 2002a).

- **Risk/Impact Module:** The Risk/Impact Module uses estimates of media- and time-specific concentrations to estimate potential impacts on the ecology of the Columbia River corridor, the health of persons who might live in or use the corridor or the upland Hanford environment, the local economy, and cultural resources. Contaminants in the environment may adversely affect human health and the environment when two conditions are met: (1) the key components of a system are exposed to the contaminant, and (2) the exposure exceeds a threshold above which effects are probable. Impact is defined as an adverse change in the system being examined. The transport modules of SAC provide estimates of contaminant concentrations from Hanford Site sources in a time-dependent manner in the vadose zone, groundwater, and the Columbia River and its associated sediments. Definitive predictions must rely on further studies to confirm that additional contaminants do not contribute appreciably to the impacts. In addition, potential inventory issues must be addressed before definitive predictions can be performed (PNNL 2002a).

5.4 FEASIBILITY STUDY

The information from the RI will be used to execute the FS in three phases: (1) the development of alternatives, (2) the screening of alternatives, and (3) the detailed analysis of alternatives. A human health risk assessment will be completed as part of the RI. The results of the human health risk assessment will be used to develop RAOs specifying the contaminants of interest, exposure pathways, and preliminary remediation goals (PRGs). The PRGs will be developed on the basis of chemical-specific applicable or relevant and appropriate requirements (ARARs) (when available), the site-specific risk assessment, and other available information.

Ecological risk will also be considered during the RI/FS. Existing information and analysis indicate that the exposure pathways from groundwater to terrestrial ecological receptors in the 200 Areas are incomplete. The ecological risk to receptors in the Columbia River environment (riparian zone and river) will be evaluated.

General response actions will be developed that may include, but are not limited to, the following:

- No action
- Institutional controls
- Monitoring natural attenuation
- Permeable or impermeable containment
- Pump-and-treat
- Air sparging.

Other technologies that may be considered are described in the *Hanford 200 West Area Carbon Tetrachloride Project Innovative Technology Review 1999-2000* (Siegal et al. 2003).

These actions may be taken singly or in combination (e.g., pumping and ex situ treatment of groundwater) to satisfy the remedial action objectives for the 200-ZP-1 OU.

Groundwater volumes or areas will be identified, to which general response action might be applied. The FS will identify and screen technologies applicable to reach general response action to eliminate those that cannot be implemented technically at the site. The general response actions will be further defined to specify remedial technology types (e.g., chemical versus biological in situ treatment).

Technology process options will be identified and evaluated in order to select a representative process for each technology type retained for consideration. The first phase of the FS will be completed by assembling the selected representative technologies into alternatives representing a range of treatment and containment combinations, as appropriate.

The FS will document the detailed analysis of alternatives. The nine evaluation criteria include two *threshold criteria*:

- Overall protection of human health and the environment
- Compliance with ARARs.

The evaluation criteria include five primary *balancing criteria*:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The evaluation criteria include two *modifying criteria*:

- State acceptance
- Community acceptance.

5.4.1 No Action

The National Contingency Plan (40 CFR 300) requires that a no action alternative be evaluated as a baseline for comparison with other alternatives. The no action alternative represents a situation where no restrictions, controls, or active remedial measures are applied to the 200-ZP-1 OU. No action implies a scenario of walking away from the site and taking no measures to monitor or control contamination. The no action alternative requires that a site pose no unacceptable threat to human health and the environment. Current information indicates that some form of action is required.

5.4.2 Institutional Controls

Institutional controls refer to physical and/or legal barriers to prevent access to contaminants and are combined with some level of monitoring. Institutional controls are usually required when contamination is left in place above cleanup levels.

Physical methods of controlling access to groundwater are access controls, which include signs, entry control, artificial or natural barriers, and active surveillance. Physical restrictions are effective in protecting human health by reducing the potential for contact with contaminated media and avoiding adverse environmental, worker safety, and community safety impacts that arise from the potential release of contaminants. If used alone, however, physical restrictions are not effective in achieving containment, removal, or treatment of contaminants. They also require ongoing monitoring and maintenance.

Legal restrictions include both administrative and real property actions intended to reduce or prevent future human exposure to contaminants remaining within the aquifer by restricting the use of the groundwater. Land-use restrictions and controls on real property development are effective in providing a degree of human-health protection by minimizing the potential for contact with contaminated media. Restrictions can be imposed through land covenants, which would be enforceable through lawsuits by the United States, under Washington State law, and EPA. They also avoid adverse environmental, worker safety, and community safety issues that could arise from the potential release of contaminants associated with other remedial technologies (e.g., treatment). Land-use restrictions are somewhat more effective than access controls if control of a site transfers from RL to another party because they use legal and administrative mechanisms that are already available to the community and the state.

The disadvantages of land-use restrictions are similar to those for access control in that they do not contain, remove, or treat contaminants. Also, land-use restrictions are not self-enforcing. They can only be triggered by an effective system for monitoring land use to ensure compliance with the imposed restrictions.

5.4.3 Monitoring Natural Attenuation

Monitored natural attenuation (MNA) is not a "technology," but rather describes a range of physical and biological processes which, unaided by deliberate human intervention, reduce the concentration, toxicity, or mobility of chemical or radioactive contaminants. These processes take place whether or not other active cleanup measures are in place. However, techniques and technologies for predicting and monitoring natural attenuation are being developed.

The mechanisms of natural attenuation can be classified as destructive and nondestructive. Destructive processes include biodegradation and hydrolysis. Biodegradation is by far the most prevalent destructive mechanism. Biodegradation, also called bioremediation, is a process in which naturally occurring micro-organisms (e.g., yeast, fungi, and bacteria) break down target contaminants (e.g., fuels, chlorinated solvents, and metals) into less toxic or non-toxic substances. Like larger living things, these microbes must eat organic substances to survive. Certain micro-organisms digest fuels, chlorinated solvents, and other substances found in the subsurface environment. Nondestructive attenuation mechanisms include sorption, dispersion, dilution, and volatilization. Dilution, dispersion, and sorption are generally the most important nondestructive mechanisms.

Long-term monitoring is necessary to demonstrate that contaminant concentrations continue to decrease at a rate sufficient to ensure that they will not become a health threat or violate regulatory criteria. Monitoring should be designed to verify that potentially toxic transformation products are not created at levels that are a threat to human health; that the plume is not expanding; that there are not releases that could affect the remedy; and that there are no changes in hydrogeological, geochemical, or microbiological parameters that might reduce the effectiveness of natural attenuation.

The EPA provides guidance for use of MNA in the Office of Solid Waste and Emergency Response (OSWER) directive, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites* (EPA 1999). This OSWER directive identifies three lines of evidence for evaluating MNA:

- Site data that clearly indicate the plume is shrinking or stable before impacting receptors
- Site data that identify the natural attenuation process and rate of these processes relative to reaching remediation goals
- Laboratory or field tests that quantify specific natural attenuation processes and rates.

If site data are insufficient to develop the first line of evidence, then the second and third lines of evidence need to be developed with a sufficient technical basis to support remediation decisions.

Specific steps for determining whether MNA can meet remediation goals for chlorinated solvents are provided in *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (EPA MNA protocol) (EPA 1998). Briefly, this protocol outlines data and analysis requirements that include the following:

- Site characterization
- An initial screening assessment to verify that site conditions are consistent with the conditions needed for natural attenuation processes
- Developing "lines of evidence" that natural attenuation is occurring demonstrating (e.g., through fate and transport modeling) that natural attenuation is likely to mitigate plume migration and meet remediation goals.

If MNA is selected as the remedy, it is implemented using a monitoring plan designed to verify that natural attenuation processes continue to attenuate the plume and that remediation goals are met over time.

Current DOE Office of Environmental Management efforts include a project focused on providing improved approaches for evaluating and implementing MNA (DOE-EM MNA Project). The primary approach identified by this project involves assessing plume-contaminant loading and the attenuation capacity within the groundwater-flow setting to determine whether the natural attenuation processes will effectively mitigate plume migration. This approach requires specific types of characterization data and analyses that are consistent with the current EPA MNA protocol.

Accelerated natural attenuation is another alternative that will be evaluated. This alternative uses a metals remediation compound for accelerating in situ metals cleanup in groundwater systems. One method of accelerating natural attenuation is through metals immobilization, where highly mobile metals in the aqueous phase are transferred to a solid stable phase that becomes part of the soil. The most common mechanisms of in situ metals immobilization are metals absorption to soil particles or precipitation of metal solids that are chemically fixed to soil particles.

5.4.4 Permeable or Impermeable Containment

The intent of the permeable or impermeable containment alternative is to contain groundwater contamination through the use of either permeable or impermeable barriers. Examples of permeable barriers include the In Situ Redox Manipulation (ISRM) technology and vertical hydraulic fracturing. The ISRM technology creates a permeable treatment zone that removes contaminants from the groundwater by converting the contaminants to a different valence state that is less hazardous. Contaminants in groundwater flowing through the treated zone are then converted to a less hazardous form.

Vertical hydraulic fracturing is a second method that could be used to install a permeable iron-reactive barrier. This reactive barrier would be installed perpendicular to the groundwater flow direction using hydraulic fracturing technology. Similar to ISRM, wells would be installed at 4.6- to 15.2-m (15- to 50-ft) spacing across the downgradient edge of the contaminant plume, creating vertical fracturing in the formation. Iron filings are then injected into the vertical fractures to complete the permeable barrier. Sheet piling is often driven into the aquifer to re-direct the groundwater to flow through the iron-reactive barrier. As the contaminants pass through the permeable barrier, their valance state is changed, making them less hazardous.

Impermeable barriers that could be considered include the use of a cryogenic coil barrier, sheet piling, or grout curtain, or creating a groundwater mount using injected clean water. Cryogenic coils could either be used to freeze the entire contaminant plume in place or could be used to create a frozen wall of groundwater that would prevent the downgradient migration of the contaminant plume. Sheet piling or a grout curtain could either be used in combination with a permeable barrier or by itself. In the former case, sheet piling or a grout curtain could be used to channel groundwater towards a permeable barrier. In the latter case, sheet piling or a grout curtain could be used by itself to create an impermeable barrier that would trap the plume preventing migration. Finally, a number of injection wells could be installed downgradient of the contaminant plume. Injecting clean water into these wells would create a wall that would contain the plume. The use of impermeable barriers to control the migration of contamination would need to be combined with some form of institutional controls to prevent the usage of contaminated groundwater within the contained area.

5.4.5 Air Sparging

Air sparging involves the injection of air or other gases directly into the groundwater to vaporize and recover VOCs from the groundwater. Injected air moves laterally driven by the injection pressure and upward due to the buoyancy of air. As the injected air moves through a formation and comes in contact with VOCs (either dissolved or in the form of DNAPL), the volatile contaminants partition into the air. Partitioning from the dissolved phase is described by a compound's Henry's law constant, while partitioning from DNAPL is described by its vapor pressure. Oxygen present in the injected air will dissolve in the water, which promotes the in situ biodegradation of nonvolatile contaminants.

5.4.6 Pump-and-Treat

The pump-and-treat alternative entails the design and implementation of an onsite 200-ZP-1 pump-and-treat system to accelerate removal and decrease the size of contaminant plumes. The objective of the pump-and-treat system would to capture the groundwater contaminant plume using extraction wells to prevent further contaminant migration, treat the extracted water onsite, then reinject the treated water upgradient of the plume. This alternative would evaluate the option of using one or more agents to assist in mobilizing selected contaminants (lixiviant), then capturing the contaminants with the downgradient extraction wells. This alternative would need to be supported by groundwater modeling to define the optimum location for the extraction wells and to ensure that the plume is fully captured. This alternative would require treatment filter regeneration and/or disposal.

5.5 PROPOSED PLAN

The proposed plan will identify a preferred alternative and present the alternative to the public for review and comment. The proposed plan will also provide a summary of the investigations for the 200-ZP-1 OU, the data generated from the various investigations, and the conclusions derived from the data. The proposed plan will also summarize the results of the FS and the basis for the action(s) proposed to be taken to remediate the site. It will include a summary of the remedial action and a schedule for implementation.

5.6 COMMUNITY RELATIONS

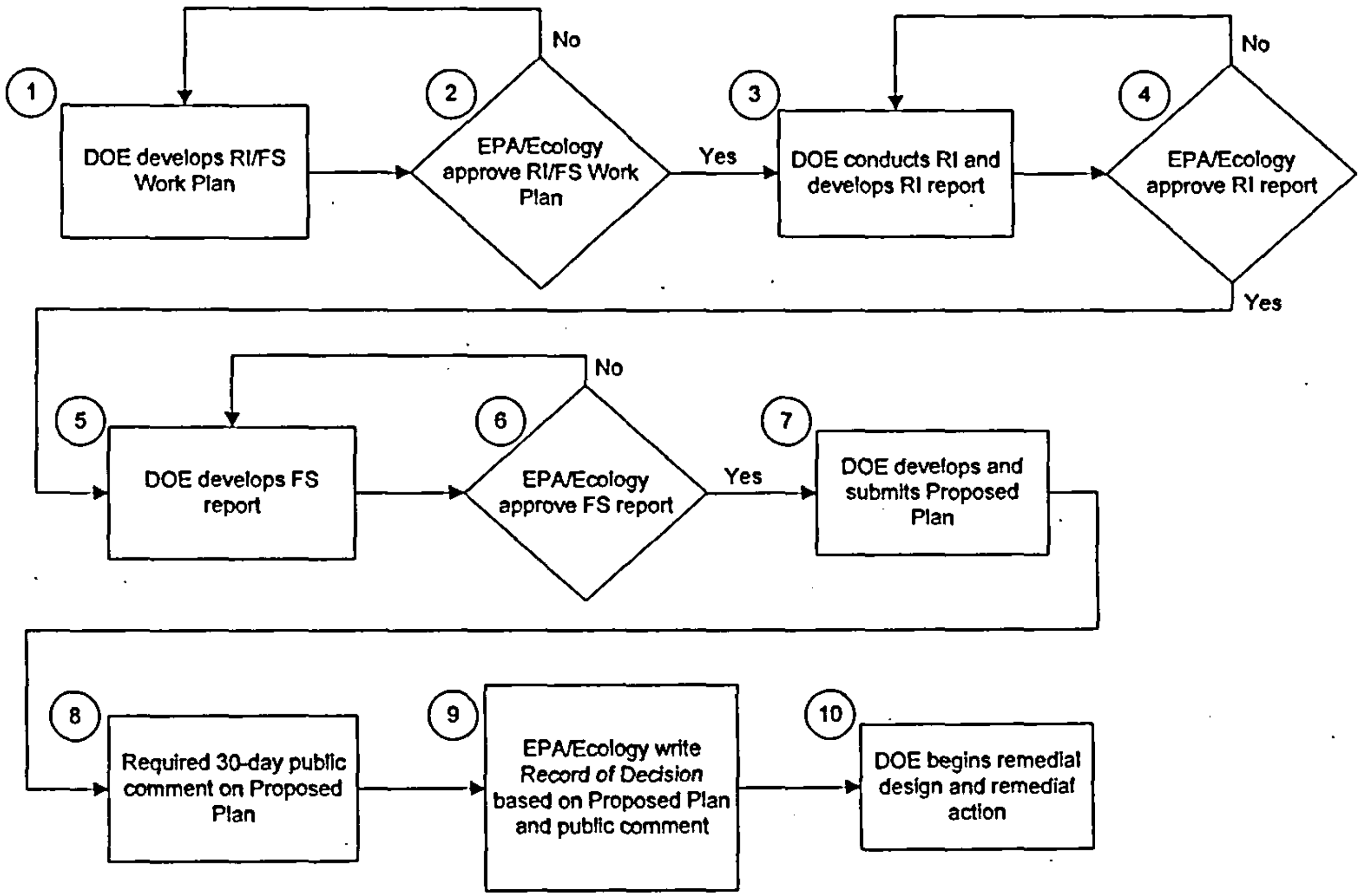
The *Hanford Site Tri-Party Agreement Community Relations Plan* (DOE et al. 2002) outlines the public participation processes implemented by the Tri-Parties (i.e., Ecology, DOE, and EPA) under authority of the Tri-Party Agreement (Ecology et al. 2003) and identifies several ways the public can participate in the Hanford Site cleanup decision-making process. These participation outlets include contact information, how to obtain publications on Hanford cleanup activities, news media activities, public involvement and comment, etc. The community relations plan can be accessed on the Internet at http://www.hanford.gov/crp/toc.htm.

The Tri-Parties conduct public involvement and information activities both cooperatively and independently. The community relations plan intends to fulfill applicable state and Federal laws regarding the development of community involvement and public participation plans. The plan also serves as one of the overall public participation plans guiding public involvement at the Hanford Site. Additional project-specific public participation plans are developed as needed at the Hanford Site. For the 200-ZP-1 Groundwater Project, a project-specific community relations plan is not planned.

In the CERCLA process (Figure 5-3), the proposed cleanup plan must undergo a 30-day public comment period before a decision is made. A public meeting may be requested on the plan during the comment period by contacting the Hanford Cleanup Line at 1-800-321-2008.

This document will be placed in information repositories as listed in the *Hanford Site Tri-Party Agreement Community Relations Plan* (DOE et al. 2002).

Figure 5-3. Tri-Party Agreement *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* Remedial Investigation/Feasibility Study Decision Process (DOE et al. 2002).



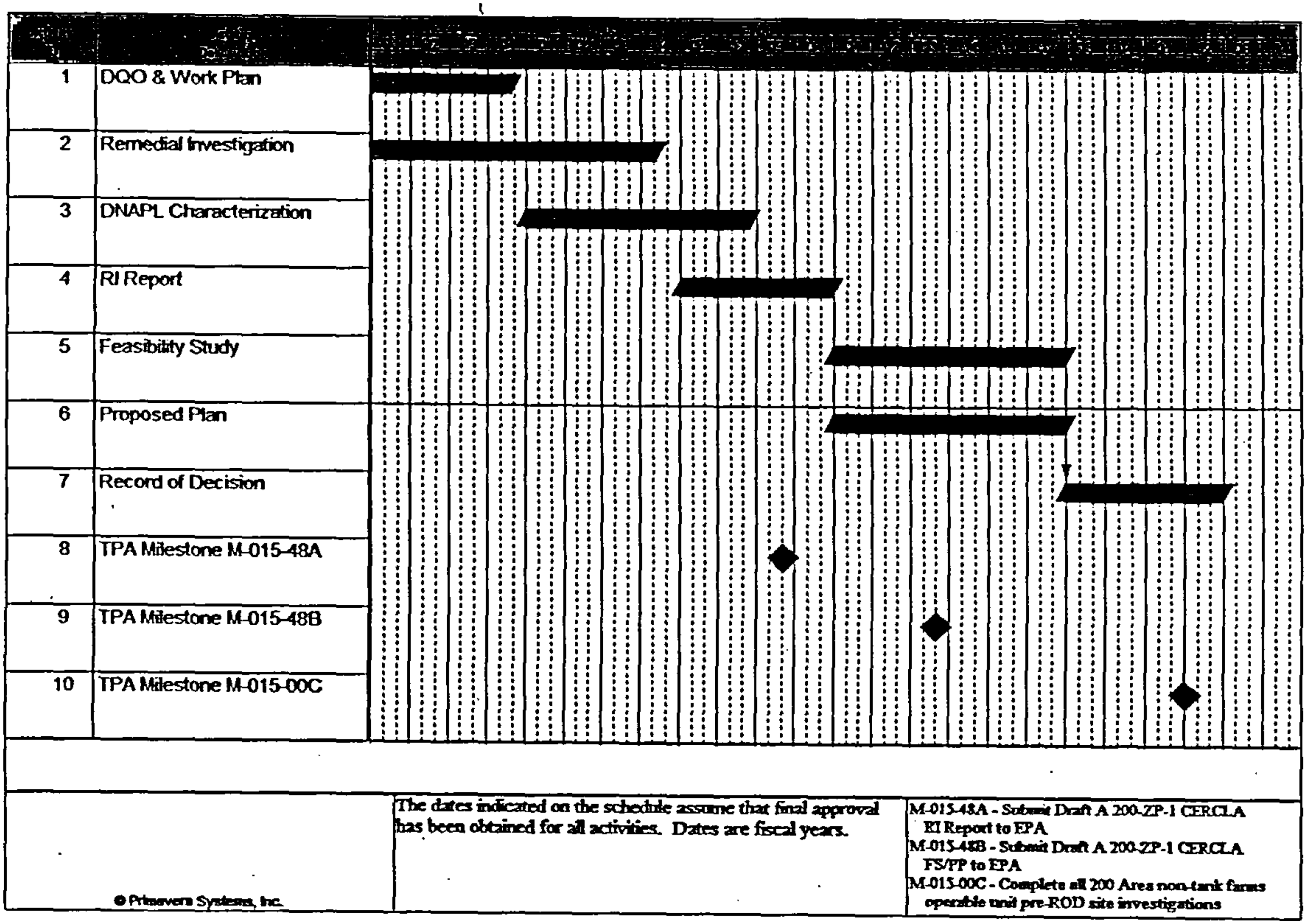
DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
RI/FS = remedial investigation/feasibility study

6.0 PROJECT SCHEDULE

Tri-Party Agreement Milestone M-13-00 (Ecology et al. 2003) requires the submission of 200 Area RI/FS work plans by December 31, 2004. Milestone M-15-00 requires completion of the pre-ROD 200 Area RI/FS process for all non-tank farm OUs by December 31, 2008. Tri-Party Agreement Milestone M-16-00 requires the completion of remedial actions for all non-tank farm OUs by September 30, 2024.

The project schedule for activities discussed in this work plan is provided in Figure 6-1 and is consistent with Tri-Party Agreement milestones. Due to the complexity of completing the DNAPL characterization (see Section 5.1.8) within the 200-ZP-1 OU, 4 years is required to complete this CERCLA RI/FS process as opposed to the typical 3-year period that is commonly used for other Hanford RI/FS processes. This schedule will serve as the baseline for the work planning process and will be used to measure the progress of implementation of this process. The schedule for the RI activities and the preparation, review, and issuance of the RI report, the FS, and the proposed plan are also shown in Figure 6-1. The schedule concludes with the preparation of a ROD.

Figure 6-1. Project Schedule for Activities.



7.0 REFERENCES

40 CFR 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," *Code of Federal Regulations*, as amended.

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

Atomic Energy Act of 1954, 42 U.S.C. 2011, et seq.

Barry, S. D., 1997, *Hanford Tank Farms Vadose Zone TX Tank Farm Report*, GJO-97-13-TAR GHO-HAN-11, MACTEC-ERS Hanford, Richland, Washington.

BHI, 1995a, *200-ZP-1 Groundwater Sampling and Analysis Plan/Quality Assurance Plan*, BHI-00038, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1995b, *Borehole Summary Report for the 200-UP-1 Operable Unit, 200 West Area*, BHI-00150, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1995c, *Borehole Summary Report for the 200-UP-2 Operable Unit, 200 West Area*, BHI-00034, Rev. 1, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1995d, *T Plant Aggregate Area Management Study Technical Baseline Report*, BHI-00177, Rev. 0, Bechtel Hanford Company, Richland, Washington.

BHI, 1999a, *Groundwater/Vadose Zone Integration Project: Preliminary System Assessment Capability Concepts for Architecture, Platform, and Data Management*, CCN 0512242, letter report dated September 30, 1999, Bechtel Hanford, Inc., Richland, Washington (available on the Internet at http://www.hanford.gov/cp/gpp/modeling/sacarchive.cfm).

BHI, 1999b, *Hydrogeologic Conceptual Model for the Carbon Tetrachloride and Uranium/ Technetium Plumes in the 200 West Area: 1994 Through 1999 Update*, BHI-01311, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2000, *Groundwater/Vadose Zone Integration Project: System Assessment Capability – Assessment Description, Requirements, Software Design, and Test Plan*, BHI-01365, Draft A, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2001, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-1 Operable Unit Phase I Representative Waste Sites*, BHI-01477, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2002a, *Carbon Tetrachloride Field Investigation Report for Drilling in the Vicinity of PFP and the 216-Z-9 Trench*, BHI-01631, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2002b, *Data Quality Objectives Summary Report for Establishing 200-ZP-1 and 200-UP-1 Groundwater Monitoring Well Network* BHI-01576, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Bryce, R. W., C. T. Kincaid, P. W. Eslinger, and L. F. Morasch, 2002, *An Initial Assessment of Hanford Impact Performed with the System Assessment Capability*, PNNL-14027, Pacific Northwest National Laboratory, Richland, Washington.

Cole, C. R., S. B. Yabusaki, and C. T. Kincaid, 1988, *CFEST-SC, Coupled Fluid, Energy, and Solute Transport Code, SuperComputer Version, Documentation and User's Manual*, Pacific Northwest Laboratory, Richland, Washington.

Cole, C. R., M. P. Bergeron, S. K. Wurstner, P. D. Thorne, S. Orr, and M. I. McKinley, 2001, *Transient Inverse Calibration of Hanford Operational Impacts – 1943 to 1996*, PNNL-13447, Pacific Northwest National Laboratory, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

DOE, 1991, *Description of Codes and Models to Be Used in Risk Assessment*. DOE/RW-9144, U.S. Department of Energy, Washington, D.C.

DOE, 2003, *Draft Hanford Site Solid (Radioactive and Hazardous) Waste Program Environmental Impact Statement (HSW EIS)*, DOE/EIS-0286, U.S. Department of Energy, Washington, D.C.

DOE, EPA, and Ecology, 2002, *Hanford Site Tri-Party Agreement Community Relations Plan*, Rev. 4, U.S. Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology, Olympia, Washington (available on the Internet at http://www.hanford.gov/crp/toc.htm).

DOE-RL, 1992a, *Quarterly Report of RCRA Groundwater Monitoring Data for Period January 1, 1992 through March 31, 1992*, DOE/RL-92-26-1, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992b, *T Plant Source Aggregate Area Management Study Report*, DOE/RL-91-61, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992c, *Z Plant Source Aggregate Area Management Study Report*, DOE/RL-91-58, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993, *200 West Groundwater Aggregate Area Management Study Report*, DOE/RL-92-16, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1995, *200-ZP-1 Operable Unit Treatability Test Report*, DOE/RL-95-30, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996a, *200 Areas Soil Remediation Strategy – Environmental Restoration Program*, DOE/RL-96-67, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996b, *200-ZP-1 IRM Phase II and III Remedial Design Report*, DOE/RL-96-07, Rev. 1, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996c, *Limited Field Investigation for the 200-UP-1 Operable Unit*, DOE/RL-96-33, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1997, *Waste Site Grouping for 200 Areas Soil Investigations*, DOE/RL-96-81, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998, *Hanford Analytical Services Quality Assurance Requirements Document*, DOE/RL-96-68, Rev. 2, Vols. 1, 2, and 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network*, DOE/RL-2002-17, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003a, *Fiscal Year 2002 Annual Summary Report for the 200-UP-1 and 200-ZP-1 Pump-and-Treat Operations*, DOE/RL-2002-67, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003b, *Hanford's Groundwater Management Plan: Accelerated Cleanup and Protection*, DOE/RL-2002-68, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003c, *Sampling and Analysis Plan for the Investigation of Dense Nonaqueous Phase Liquid Carbon Tetrachloride at the 216-Z-9 Trench*, DOE/RL-2003-41, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2004, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, DOE/RL-2001-01, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 2003, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), 2 vols., as amended, 89-10, Rev. 6, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1997, *Test Methods for Evaluation Solid Waste, Physical/Chemical Methods*, SW-846, 3rd edition (as amended by Update I [July 1992], Update IIA [August, 1993], Update IIB [January 1995], and Update III), U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1998, *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*, EPA/600/R-98/128, U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

EPA, 1999, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER Directive 9200.4-17, U.S. Environmental Agency, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2000, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, EPA/600/R-96/055, U.S. Environmental Protection Agency, Environmental Protection Office of Environmental Information, Washington, D.C.

EPA, 2001, *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, EPA/240/B-01/003, U.S. Environmental Protection Agency, Office of Environmental Information, Washington, D.C.

EPA, Ecology, and DOE, 1995, *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit*, Document #016085, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

FH, 2003a, *Data Quality Objectives Summary Report for Establishing a RCRA/CERCLA/AEA Integrated 200 West and 200 East Groundwater Monitoring Network*, CP-15329, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

FH, 2003b, *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process*, CP-16151, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

Gupta, S. K., C. R. Cole, C. T. Kincaid, and A. M. Monti, 1987, *Coupled Fluid, Energy, and Solute Transport (CFEST) Model: Formulation and User's Manual*, BMI/ONWI-660, Battelle Memorial Institute, Columbus, Ohio.

Hedges, J., 2002, *TX Tank Farm Vadose Characterization Boring Request*, letter to R. Yasek (ORP), dated March 4, 2002, Washington State Department of Ecology, Olympia, Washington.

Kincaid, C. T., M. P. Bergeron, C. R. Cole, M. D. Freshley, N. L. Hassig, V. G. Johnson, D. I. Kaplan, R. J. Serne, G. P. Streile, D. L. Strenge, P. D. Thorne, L. W. Vail, G. A. Whyatt, and S. K. Wurstner, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, PNNL-11800, Pacific Northwest National Laboratory, Richland, Washington.

Kos, S. E., 1997, *Hanford Tank Farms Vadose Zone Draft for External Technical Review Only TY Tank Farm Report*, GHO-97-30-TAR GHO-HAN-16, MACTEC-ERS Hanford, Richland, Washington.

PNNL, 2002a, *Hanford Site Groundwater Monitoring for Fiscal Year 2001*, PNNL-13788, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002b, *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*, PNNL-13858, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2002c, *User Instructions for the Systems Assessment Capability, Computer Codes, Volume 1: Inventory, Release, and Transport Modules*, PNNL-13932, Pacific Northwest National Laboratory, Richland, Washington.

PNNL, 2003, *Hanford Site Groundwater Monitoring for Fiscal Year 2002*, PNNL-14187, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

Rohay, V. J., 1993, *Carbon Tetrachloride Atmospheric Losses and Residual Inventory Beneath 200 West Area,* WHC-SD-EN-TI-101, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Siegel, M., G. Ballew, W. C. Cheng, M. Hightower, L. Maffitt, and Y. McClellan, 2003, *Hanford 200 West Area Carbon Tetrachloride Project Innovative Remediation Technology Review 1999-2000,* SAND2003-0150P, Sandia National Laboratories, Albuquerque, New Mexico.

Superfund Amendments and Reauthorization Act of 1986, 42 U.S.C. 9607, et seq.

Truex, M. J., C. J. Murray, C. R. Cole, R. J. Cameron, M. D. Johnson, R. S. Skeen, and C. D. Johnson, 2001, *Assessment of Carbon Tetrachloride Groundwater Transport in Support of the Hanford Carbon Tetrachloride Innovative Technology Demonstration Program,* PNNL-13560, Pacific Northwest National Laboratory, Richland, Washington.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code,* as amended.

White, M. D., and M. Oostrom, 2000, *STOMP – Subsurface Transport Over Multiple Phase: Theory Guide,* PNNL-11216, Pacific Northwest National Laboratory, Richland, Washington.

Wilson, B., 2001, *Findings from Groundwater Compliance Monitoring Evaluation Inspection at the T and TX/TY Waste Management Areas,* letter to K. Klein (RL) and H. Boston (ORP), dated November 20, 2001, Washington State Department of Ecology, Olympia, Washington.

Wilson, B., 2002, *T and TX/TY Waste Management Areas Regulatory Deficiencies,* letter to K. Klein (RL) and H. Boston (ORP), dated April 18, 2002, Washington State Department of Ecology, Olympia, Washington.

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APPENDIX A

SAMPLING AND ANALYSIS PLAN TO SUPPORT 200-ZP-1 GROUNDWATER OPERABLE UNIT REMEDIAL INVESTIGATION/FEASIBILTY STUDY AND LONG-TERM MONITORING

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TERMS

AA	alternative action
AEA	*Atomic Energy Act of 1954*
ASTM	American Society for Testing and Materials
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CLARC	*Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation*
COC	contaminant of concern
CRDL	contract required detection limit
DFSNW	Duratek Federal Services Northwest
DNAPL	dense nonaqueous phase liquid
DQO	data quality objective
DR	decision rule
DS	decision statement
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FH	Fluor Hanford, Inc.
FY	fiscal year
HASQARD	*Hanford Analytical Services Quality Assurance Requirements Document*
HEIS	Hanford Environmental Information System
K_d	distribution coefficient
LLWMA	Low-Level Waste Management Area
MCL	maximum contaminant level
MDC	minimum detectable concentration
N/A	not applicable
NTU	nephelometric turbidity unit
OU	operable unit
PCE	tetrachloroethylene
PNNL	Pacific Northwest National Laboratory
ppb	parts per billion
QC	quality control
RAO	remedial action objective
RCRA	*Resource Conservation and Recovery Act of 1976*
RI/FS	remedial investigation/feasibility study
RL	U.S. Department of Energy, Richland Operations Office
ROD	Record of Decision
SALDS	State-Approved Land Disposal Site
SAP	sampling and analysis plan
SSPM	*Sampling Services Procedure Manual*
TBD	to be determined
TCE	trichloroethylene
TIC	tentatively identified compound
TOC	total organic carbon

Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
VOC	volatile organic compound
WAC	*Washington Administrative Code*
XRD	x-ray diffraction

A1.0 INTRODUCTION

This sampling and analysis plan (SAP) was prepared to support the remediation of the 200-ZP-1 Groundwater Operable Unit (OU) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). This SAP consolidates the ongoing CERCLA groundwater monitoring program with the remedial investigation/feasibility study (RI/FS) characterization and supersedes DOE/RL-2002-17, *Sampling and Analysis Plan for the 200-ZP-1 Groundwater Monitoring Well Network* (DOE-RL 2002).

The 200 West Area is located on a plateau at the center of the Hanford Site. Each of the plutonium-production processes began with dissolution of the aluminum or zirconium-cladding material on fuel rods in solutions containing ammonium hydroxide, ammonium nitrate, and ammonium fluoride, followed by dissolution of the irradiated fuel slugs in nitric acid. This chemical-processing step produced large quantities of nitric acid solutions containing high levels of radioactive materials. After the plutonium and uranium were recovered, wastes were disposed to the ground or were neutralized and stored in large underground tanks.

This SAP contains three major sections:

- Section A1.0 – Summarizes the recent data quality objectives (DQO) process output and the data needs.
- Section A2.0 – Provides the quality assurance project plan.
- Section A3.0 – Provides the field sampling plan.

It should be noted that select tables do not appear in the order discussed. The goal is to provide the tables where they will be the most beneficial to the user. For example, the field sampling team needs the location and analyte list by well presented in Section A3.0; therefore, the reader is referred to these tables in Section A1.3. By using this approach, redundancy is prevented and quality maintained by placing the correct information in one location.

A1.1 CONTAMINANTS OF CONCERN

A1.1.1 Routinely Monitored List of Contaminants of Concern

The middle column in Table A1-1 presents a list of groundwater contaminants of concern (COCs) generated for the 200-ZP-1 OU to fulfill the routine monitoring requirements for the combined *Resource Conservation and Recovery Act of 1980* (RCRA)/CERCLA/*Atomic Energy Act of 1954* (AEA) groundwater monitoring network (FH 2003a). This list was generated to fulfill current monitoring requirements for the RCRA/CERCLA/AEA contaminants. The initial list of COCs also provided the baseline monitoring list for consideration in the RI/FS DQO summary report (FH 2003b). Based on the evaluation of monitoring results from individual wells (discussed in Appendix C), several additional COCs were added to the routine analyses of the monitoring well network for specific wells. These additional routine monitoring COCs are also listed in Table A1-1. Table A1-1 identifies the COCs currently requested for reporting during routine groundwater monitoring at the 200-ZP-1 OU.

Table A1-1. Routinely Monitored Contaminants of Concern.

Media	RCRA/CERCLA/AEA Routine Monitoring COCs (FH 2003a)	Additional Monitoring COCs from 200-ZP-1 Data Evaluation (FH 2003b)
Radiological		
Groundwater	I-129, Tc-99, uranium, H-3, Sr-90	None
Nonradiological		
Groundwater	Carbon tetrachloride, chloroform, trichloroethylene (TCE), chromium (total), arsenic, cadmium, nitrate	Antimony, iron, methylene chloride, manganese, benzene, 1,2-dichloroethane, tetrachloroethylene, fluoride

AEA = *Atomic Energy Act of 1954*
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
COC = contaminant of concern
RCRA = *Resource Conservation and Recovery Act of 1976*

A1.1.2 Additional Contaminants of Concern Resulting from 2003 Data Quality Objective Process

A second DQO process conducted in 2003 to support the RI/FS process for 200-ZP-1 OU evaluated additional data needs for determining the nature and extent of contamination in the groundwater (FH 2003b). Six documents provided the majority of historical information regarding COCs:

- *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-1 Operable Unit Phase I Representative Waste Sites* (BHI 2001)
- *Drilling, Sampling, and Analysis Plan for Installation of a Well Within the Vicinity of the Plutonium Finishing Plant* (DOE-RL 2001)
- *200 West Groundwater Aggregate Area Management Study Report* (DOE-RL 1993)
- *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program* (DOE-RL 1999)
- *T Plant Source Aggregate Area Management Study Report* (DOE-RL 1992b)
- *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site* (Kincaid et al. 1998).

Each of these documents lists the radioactive and nonradioactive constituents that were measured and/or suspected to be in the groundwater or that would be released to the groundwater in the future. A list was prepared containing all of the COCs based on historical lists in these reference documents, and an evaluation was then performed to determine if any of the COCs could be eliminated because of short half-lives, low potential dose/risk rates, high soil retardation, or other factors. These COCs were determined using an elimination process, which is detailed in the RI/FS DQO summary report (FH 2003b). The results of the evaluation are presented below. Table A1-2 presents the final list of COCs (including routinely monitored COCs from Table A1-1) for the 200-ZP-1 Groundwater OU.

Table A1-2. Final List of Contaminants of Concern in the 200-ZP-1 Groundwater Operable Unit. (2 sheets)

Radiological COCs		Nonradiological COCs
COC Element	**COC Isotope**	**Metals**
Beta Emitters		Antimony
Carbon	C-14	Arsenic
Iodine	I-129	Cadmium
Selenium	Se-79	Chromium
Strontium	Sr-90	Chromium (hexavalent)
Technetium	Tc-99	Iron
Tritium	H-3	Lead
Alpha Emitters		Lithium
Neptunium	Np-237	Magnesium
Protactinium	Pa-231	Manganese
Uranium	U-234	Mercury
Uranium	U-235	Nickel
Uranium	U-238	Selenium
Gamma Emitters		Silver
Cesium	Cs-137	Uranium
		Volatile Organics
		Acetone
		Benzene
		Carbon disulfide
		Carbon tetrachloride[a]
		Chloroform
		Chlorobenzene
		Ethyl benzene
		Methylene chloride
		Methyl ethyl ketone
		4-methyl-2-pentanone (hexone, MIBK)
		N-butylbenzene

Table A1-2. Final List of Contaminants of Concern in the 200-ZP-1 Groundwater Operable Unit. (2 sheets)

Radiological COCs	Nonradiological COCs
	1,2-dichloroethylene (cis and trans)
	1,2-dichloroethane (DCA)
	Toluene
	1,1,1-trichloroethane (TCA)
	Trichloroethylene (TCE)
	Tetrachloroethylene (PCE)
	Xylene (total)
	Non-Metals
	Ammonium
	Cyanide
	Fluoride
	Nitrite
	Nitrate
	Phosphate[b]
	Semi-Volatile Organics
	Cresols
	Kerosene
	Phenols (total)

[a] Carbon tetrachloride is being remediated in accordance with the 200-ZP-1 Record of Decision (EPA et al. 1995).
[b] Includes orthophosphate plus organo-phosphates.
COC = contaminant of concern

A1.2 DATA QUALITY OBJECTIVES

The U.S. Environmental Protection Agency's (EPA's) *Guidance for the Data Quality Objectives Process* (EPA 2000) was used to support the development of this SAP. The DQO process is a strategic planning approach for defining the criteria that a data collection design should satisfy. Using the DQO process ensures that the type, quantity, and quality of environmental data used in decision making will be appropriate for the intended application.

This section presents only a summary of the key outputs resulting from the DQO process. For additional details, refer to the RI/FS DQO summary report (FH 2003b).

A1.2.1 Statement of the Problem

The problem addressed by the RI/FS DQO summary report (FH 2003b) is to ensure that adequate data are available to support the RI/FS process as applied to the 200-ZP-1 OU. This support includes providing data that can be used to support necessary risk modeling and prediction, to make decisions regarding various alternative remedial actions, to provide data to judge the effectiveness of interim remedial actions, and to fulfill long-term CERCLA monitoring needs.

A1.2.2 Decision Statements and Decision Rules

The decision statements (DSs) consolidate potential questions and alternative actions (AAs). Decision rules (DRs) are generated from the DSs. A DR is an "IF...THEN..." statement that incorporates the parameter of interest, unit of decision making, action level, and action(s) that would result from resolution of the decision. Table A1-4 presents the DRs in tabular format that corresponds to each of the DSs identified in Table A1-3. The table headers for Table A1-4 include the following:

- The population parameter is the population being evaluated.
- The sample statistic may or may not apply and is often a mean or upper confidence limit.
- The variable is the analyte and any concentration or units.
- The unit or scale of decision making is the smallest subset of the population for which a decision can be made.
- The relationship is normally "greater than" or "less than," but these have been altered in this DQO summary report to better fit the situation.
- The AAs are the actions one chooses between after the data are compiled and evaluated.

Table A1-3. Decision Statements. (2 sheets)

DS #	Decision Statement
1	Determine whether acceptable source-term and/or groundwater COC data are available to allow a decision (e.g., through modeling or technical judgment) to accept or reject a COC, or are additional data needed?
2	Determine whether groundwater modeling input parameters (e.g., groundwater flow rate, direction, and mixing depth) are known and allow modeling of future movement of COCs in the groundwater, or are additional data needed?
3	Determine whether sufficient data are available to determine the horizontal and vertical distribution of COCs in the unconfined aquifer, or are additional data required?
4	Determine whether sufficient data are available to allow the evaluation of initial candidate remedial alternatives, or are additional data required?
5	Determine whether the COCs currently measured in the groundwater, or those expected to reach the groundwater in the next 1,000 years, exceed applicable risk levels at defined boundaries and, therefore, require monitoring and/or remediation, or is only long-term monitoring required?
6	Determine whether the data necessary to choose between final remedial action alternatives for a specific plume are available, or are additional data needed?
7	Determine whether an adequate number of wells are in place to monitor whether RAOs have been met, or are additional wells needed?

Table A1-3. Decision Statements. (2 sheets)

DS #	Decision Statement
8	Determine whether RAOs have been achieved allowing remedial action to cease, or must remedial action continue?

COC = contaminant of concern
RAO = remedial action objective

Several of the DSs require professional judgment to evaluate data from widely differing sources and quality. In some cases, the data needed to use a specific DR are not currently available. As discussed in RI/FS DQO summary report (FH 2003b), the data required to make the decisions do not necessarily relate to a single sample statistic. Consequently, the DRs are more complicated than a simple comparison of a single analyte to a specific regulatory action level. Sentences for each DR would be unwieldy and difficult to follow; thus, a tabular format was chosen for presentation of the DRs in Table A1-4.

A1.2.3 Error Tolerance and Decision Consequences

Generally speaking, traditional statistical sampling designs are not feasible for groundwater investigations based on a number of factors, including the high cost of well installation.

Because analytical data can only estimate the true condition of the site under investigation, decisions made based on measurement data could potentially be in error (i.e., decision error). Therefore, DQO Step 6 in the RI/FS DQO summary report (FH 2003b) determined whether any DSs required a statistically based sample design. The DSs resulted in the resolution of several of the DRs requiring professional judgment to assess the adequacy of data that are available and to determine whether data are missing or if available data should be augmented.

Because DS #1 through DS #6 in the RI/FS DQO summary report (FH 2003b) supporting this SAP did not require traditional statistical calculations, tables defining the null hypothesis, alpha and beta error, and width of the gray region were excluded. The determination of whether additional wells are needed to adequately monitor remedial action will be determined on a case-by-case basis and will use geostatistical models (DS #7). The determination whether the remedial action objective (RAO) for a specific COC in the groundwater has been met (DS #8) may be amenable to a statistical design. At present, no final remedial action has been chosen, and a statistical design for determining the success or failure was not part of the DQO process. Table A1-5 provides the proposed non-statistical sampling design for each DS.

Table A1-4. Decision Rules for Each Decision Statement. (3 sheets)

DR #	Population Parameter	Sample Statistic	Variable[a] Attribute	Variable[a] Unit of Measure	Unit or Scale of Decision Making	Relationship	Target Action Level	AA #1	Relationship	AA #2
1	If the concentration of all potential COCs in groundwater (Tables A1-1 and A1-2)	As estimated by representative values from historical analytical and process data or through modeling *source terms*	Of the COCs estimated in pCi/L or other appropriate units		In the groundwater within the geographic boundaries[a] over the next 0.5 years	Are reliably known[b]	Based on professional judgment of RL, the regulators, and contractor staff	Gather no more data	or	Gather additional data.
2	If saturated zone model input parameters	As estimated by representative values	Of the modeling input parameters measured in appropriate units		For the saturated sediments and groundwater within the geographic boundaries[a] over *the next 2 years*	Are adequately known[b]	Based on professional judgment of RL, the regulators, and contractor staff	Gather no more data	or	Gather additional data.
3	If the horizontal and vertical distribution of COCs in groundwater	As estimated by spatially defined analytical results in the groundwater	Of the COCs in pCi/L		For the saturated sediments and groundwater within the geographic boundaries[a] over the next 2 years	Are adequately known[b]	Based on professional judgment of RL, the regulators, and contractor staff	Gather no more data	or	Gather additional data.
4	If the data required to evaluate candidate remedial action alternatives	As defined by representative values	Of the COC concentration and/or strata characteristics in *the appropriate units*		For a specific groundwater COC plume within the geographic boundaries[a] over the next 2 years	Are available for comparison to[b]	The operational requirements of candidate remedial actions	Evaluate remedial action alternatives	or	Obtain data necessary to allow evaluation of remediation alternatives.

Table A1-4. Decision Rules for Each Decision Statement. (3 sheets)

DR #	Population Parameter	Sample Statistic	Variable: Attribute	Variable: Unit of Measure	Unit or Scale of Decision Making	Relationship	Target Action Level	AA #1	Relationship	AA #2
5	If the COC risk level in groundwater over the next 1,000 years	As estimated by measurement or modeling and approved risk assessment procedures	*Of the COCs in pCi/L* or µg/L		For the groundwater within the geographic boundaries[a] over the next 1,000 years	Is >	The action levels to be defined in the feasibility study and ROD	Monitor and/or remediate	or	Conduct only long-term monitoring.
6	If additional data are required to choose a final remedial action alternative	As determined by representative values	Of the COC concentration and/or strata characteristics in the appropriate units		For a specific groundwater COC plume within the geographic boundaries[a] over the next 3 years	Are not available for comparison to[b]	The operational requirements of the final remedial action alternatives	Obtain additional data through treatability tests or other means, as appropriate	or	Choose remedial action alternative.
7	*If the total* number of groundwater wells	As determined by the existing well network	In the 200-ZP-1 OU		For a specific groundwater contaminant plume within the geographic boundaries over *the next 3(+) years*	Are ≥	Minimum required by PNNL's geostatistical model	Use existing wells to monitor remedial action	or	Install additional monitoring wells.

Table A1-4. Decision Rules for Each Decision Statement. (3 sheets)

DR #	Population Parameter	Sample Statistic	Variable		Unit or Scale of Decision Making	Relationship	Target Action Level	AA #1	Relationship	AA #2
			Attribute	Unit of Measure						
8	If the post-remedial action groundwater concentration	As estimated by analytical measurements	Of the COCs in ρCi/L or µg/L		For specific groundwater COC plume within the geographic boundaries over the next 3(+) years	Are >	The established RAOs	Continue to implement remedial alternative	or	Cease remediation.

[a] Geographic boundaries consist of the groundwater beneath the core zone and outside the core zone (Figure 1 1) within the 200-ZP-1 OU.
[b] These decisions require consideration of multiple inputs and professional judgment. There is no quantitative measurement level for a statistical comparison.

AA = alternative action
COC = contaminant of concern
DR = decision rule
OU = operable unit
PNNL = Pacific Northwest National Laboratory
RAO = remedial action objective
RL = U.S. Department of Energy, Richland Operations Office
ROD = Record of Decision

Table A1-5. Statistical Versus Non-Statistical Sampling Design.

DS #	Time-Frame (Years)	Resampling Access (Accessible/Inaccessible)	Proposed Sampling Design (Statistical/Non-Statistical)
1 through 6	0 to 3	Accessible	Non-statistical; decisions will be based on analytical results over a period of time and/or through professional judgment.
7	3+	Accessible	PNNL's geostatistical model (variogram analysis combined with stochastic simulation) will be used in combination with professional judgment.
8	3+	Accessible	To be determined when final remedial action is chosen in the Record of Decision.

DS = decision statement
PNNL = Pacific Northwest National Laboratory

A1.3 SUMMARY OF DATA QUALITY OBJECTIVE RESULTS (SAMPLING DESIGN)

This section presents a summary of the supplemental data that were identified as needed to address all of the CERCLA RI/FS decisions identified in the DQO summary report (FH 2003b). This supplemental data includes the installation of eight new monitoring wells to fill gaps identified in the groundwater monitoring network and adding additional analyses to samples collected from a number of monitoring wells in the network. These supplemental analyses will determine if COCs identified in historical documents (which have not historically been tested for) are impacting groundwater quality. The supplemental data needs also include the collection of physical, geological, hydraulic, and geochemical property data and the collection of aquifer test data needed to support risk modeling and calculations. Additional deep soil and groundwater characterization data are needed to define the three-dimensional distribution of contamination within the aquifer, as well as to determine the presence of absence and three-dimensional distribution of dense nonaqueous phase liquid (DNAPL).

A1.3.1 Enhanced Groundwater Monitoring Well Network

The results from the geostatistical modeling and non-statistical evaluation concluded that the optimum number of groundwater wells to be monitored within the 200-ZP-1 OU is 71, of which 8 are new wells to be installed. The purpose of this SAP is to ensure that the data obtained from the monitoring network are adequate to support the RI/FS and ultimate closure of the 200-ZP-1 OU under CERCLA.

Of the 71 wells identified in Table A3-2 for monitoring the 200-ZP-1 OU, 63 wells currently exist and 8 are new wells to be installed. As shown on the plate map presented in Appendix B, the 63 existing wells are relatively evenly distributed within the boundaries of the COC plumes, with a tighter concentration of wells around the 2,000 µg/L carbon tetrachloride contour.

The eight new wells are positioned at locations identified as having data gaps (FH 2003a, 2003b). New wells "C," "D," "E," and "F" are proposed to be installed to refine the perimeter of the 2,000 µg/L carbon tetrachloride contour. New well "G" is proposed to be installed to refine the eastern portion of the 5 µg/L carbon tetrachloride contour. New well "H" is proposed to be installed west of T Plant to help define the spreading of the nitrate, trichloroethylene, tritium, uranium, and iodine-129 plumes, as well as to provide additional vertical distribution data (i.e., physical, geological, hydraulic, chemical, and geochemical properties) for this region of the OU. New well "I" is proposed to be installed as an upgradient monitoring well for the 200-ZP-1 OU. New well "T" is proposed to be installed due north of T Plant to define the northern edge of the nitrate, carbon tetrachloride, and tritium plume. The proposed priority in which the new 200-ZP-1 wells are currently planned to be installed is discussed in Section A3.2.

To assist in defining the three-dimensional distribution of COCs within the unconfined aquifer, approximately five depth-discrete groundwater and soil samples collected from new wells "C," "H," and 299-W15-46 (described in Section A1.3.5) shall be tested using analytical methods described in Tables A2-1 and A2-2. New wells "C" and "H" will be drilled to the top of the Ringold Lower Mud Unit, approximately 36.6 to 61 m (120 to 200 ft) below the top of the unconfined aquifer; new well 299-W15-46 will be drilled through the Ringold Lower Mud Unit to basalt.

In addition, wells, "D," "E," "F," "G," "I," and "T" (shown on the plate map in Appendix B) will be drilled 36.6 m (120 ft) below the water table and a series of depth-discrete groundwater samples will be collected beyond the samples indicated in Table A3-2. These depth-discrete samples will be collected at approximately 9.1-m (30-ft) intervals, for a total of four samples. These samples shall be analyzed for carbon tetrachloride, trichloroethylene (TCE), chloroform, and tetrachloroethylene (PCE). These four COCs have been selected as indicator COCs that will provide insight into the three-dimensional distribution of contaminants within the aquifer.

All wells will be installed with 4-in. inside-diameter, stainless-steel screens and riser pipe. The screens will be approximately 9.15 m (30 ft), and the slot size will be based on the grain-size analysis. Wells will be screened at the interval with the highest concentration of COCs. The well completion depth will vary, but the average completion depth is expected to be approximately 88.45 m (290 ft).

A1.3.2 Routine Groundwater Monitoring Strategy

Table A3-2 presents the groundwater monitoring well network updated from a previous DQO summary report (FH 2003a). The selected frequency proposed for sampling the wells is dependent upon how many times a well has been sampled in the past. New wells are to be sampled quarterly the first year after installation, semi-annually the second year after installation, then annually from that point forward. Biennial sampling (i.e., every 2 years) is used for perimeter wells that have shown stable concentrations for several years. Conversely, if a well begins to show stable concentrations, the sampling frequency may decrease. If irregular or increasing trends appear, the sampling frequency may increase accordingly. Table A3-2 lists the existing and proposed wells in the 200-ZP-1 OU monitoring well network, presents the sample analyses for individual wells, and indicates the frequency at which samples will be collected.

With regard to the new groundwater monitoring wells proposed within the 200-ZP-1 OU, these wells will be installed in the out-years based on the priority given in Table A3-1 and budget availability.

A1.3.3 Monitoring for Additional Contaminants of Concern

During the preparation of the 200-ZP-1 DQO summary report (FH 2003b), a number of historical documents were researched for the purpose of identifying a comprehensive list of contaminants of potential concern (COPCs) that should be taken into consideration when going through the CERCLA RI/FS process. A number of these COPCs were able to be eliminated after reviewing historical analytical data, radioactive half-life, soil adsorption, and toxicity. Those COPCs that were retained became the COCs that are undergoing evaluation in this work plan. Appendix D of the DQO summary report (FH 2003b) contains a list of all COPCs and the rationale for their inclusion or exclusion as COCs.

The implementation strategy to obtain information regarding these additional COCs is to sample specific wells in high-concentration areas of the plumes and/or at wells immediately downgradient from selected waste sites. Two rounds of sampling are schedule: the first in fiscal year 2004 (FY04), and the second in FY06. The results of the sampling and analysis will be evaluated and, if one or more of these additional COCs are detected, the supporting SAP will be updated to add these COCs to the routine sampling program. If the additional COCs are not detected, they will not be considered further in the RI/FS process. Table A3-3 presents the wells that have been chosen for this additional sampling. These wells will be analyzed for the COCs listed in Table A2-1 according to the listed methods.

A1.3.4 Modeling Input Parameters

The needed modeling input data (identified in Table A2-2) will be collected from the saturated zone of three selected wells (new wells "C," "H," and 299-W15-46) within the 200-ZP-1 OU or will be collected from these selected wells following well installation (e.g., well development and aquifer testing). These three wells were selected based on professional judgment to be representative of the 218-W-4B/218-W-2 Burial Grounds, T Plant, and Z Plant, respectively. The approximate locations for new wells "C" and "H" are shown on the plate map in Appendix B. Well 299-W15-46 is currently being drilled on the south side of the Z-9 Crib.

Table A1-6 identifies the modeling input parameter sampling and analysis requirements. Approximately five depth-discrete groundwater and soil samples shall be collected during drilling of the three identified new wells. These samples shall be approximately evenly spaced between the top of the water table and the top of the Ringold Lower Mud Unit, or about 36.6 to 61.0 m (120 to 200 ft) below the top of the unconfined aquifer. Well 299-W15-46 will be drilled through the Ringold Lower Mud Unit to basalt, and an additional groundwater sample shall be collected from this interval. These samples shall be analyzed for the parameters identified in Table A2-2. These samples shall also be tested for the parameters identified in Table A2-1, as discussed in Section A1.3.3.

These three new wells will be completed to screen the upper portion of the unconfined aquifer unless the highest concentration of contaminants is found at a deeper interval. In the latter case, the U.S. Department of Energy, Richland Operations Office (RL) and EPA will be consulted on the interval to be screened. The data obtained from these wells will allow more accurate modeling of plume movement and knowledge of the vertical distribution of the COCs.

Table A1-6. Model Input Parameter Sampling and Analysis Requirements for 200-ZP-1 Operable Unit New Groundwater Wells.

New Well Name	Physical/ Geological Properties from Table A2-2	Hydraulic Properties from Table A2-2	Geochemical Properties from Table A2-2	K_d for Specific COCs	Deep Well	Rationale for Selecting Well
C[b]	X	X	X	X	X	This location could help determine the source of carbon tetrachloride contamination recently detected upgradient of the TX-TY Tank Farm. It is located downgradient of burial ground LLWMA 4. In addition, well "C" is located within a nitrate plume.
299-W15-46[a]	X	X	X	X	X	This location has historically shown some of the highest concentrations of carbon tetrachloride with depth within the aquifer. In addition, it is within several other plumes including chloroform, nitrate, and trichloroethylene.
H[b]	X	X	X	X	X	This location is to the west of T Plant and is inside or adjacent to several groundwater plumes that include I-129, nitrate, trichloroethylene, tritium, and uranium. Depth-discrete groundwater samples from this location will help verify the depth interval where contaminants are concentrated.

[a] This well is to be drilled in fiscal year 2003 near the Z-9 Crib. It has tentatively been named well 299-W15-46 (note that this name may change). It will be drilled to basalt.
[b] Wells "C" and "H" will be drilled to the top of Ringold Lower Mud Unit.
COC = contaminant of concern
K_d = distribution coefficient
LLWMA = Low-Level Waste Management Area

A1.3.5 Three-Dimensional Distribution of Contaminants of Concern

To assist in defining the three-dimensional distribution of COCs within the unconfined aquifer, approximately five depth-discrete groundwater and soil samples collected from new wells "C," "H," and 299-W15-46 (described in Section A1.3.4) shall also be tested using the analytical methods described in Table A2-1. Note that these samples shall also be tested for the modeling input parameters described in Table A2-2.

In addition, wells "D," "E," "F," "G," "I," and "T" (shown on the plate map in Appendix B) will be drilled 36.6 m (120 ft) below the water table, and a series of depth-discrete groundwater samples will be collected beyond the samples indicated in Table A3-2. The depth-discrete samples will be collected at approximately 9.1-m (30-ft) intervals, for a total of four samples. These samples shall be analyzed for carbon tetrachloride, TCE, chloroform, and PCE. These four COCs have been selected as indicator COCs that will provide insight into the three-dimensional distribution of contaminants within the aquifer.

A1.3.6 Aquifer Testing

Detailed hydrologic testing will be conducted at approximately three well locations to provide required input characterization parameters for numerical groundwater models needed to evaluate fate and transport of contaminants. In general, from one to three hydrologic tests will be conducted at each of these well sites. Hydrologic tests that may be performed include the following: slug tests, slug interference tests, constant-rate discharge tests, and tracer tests (e.g., single- or dual-well tests).

Multiple depth intervals may be tested to provide an indication of the vertical distribution of hydraulic properties. For wells that are drilled to the Ringold Lower Mud Unit (Unit 9), as many as three depth intervals may be tested: one at the top of the aquifer, one at an intermediate zone, and one at the bottom of the unconfined aquifer. For wells that are already completed in the upper part of the aquifer, only the upper interval will be tested.

Hydrologic parameters of primary interest include the following: hydraulic conductivity, vertical anisotropy, longitudinal and transverse dispersivity, and effective porosity. Preference in the test characterization will focus on the use of test methods that provide larger-scale hydraulic property values, because this is consistent with the scale currently used by Hanford Site groundwater models. It is recognized that the disposal of purgewater (which may be generated using constant-rate discharge tests) may pose a problem at some well site locations. In these instances, the use of constant-rate discharge testing may be limited; however, high priority will be given for testing the upper test interval in all wells (if possible) using this characterization method. Other hydrologic testing methods can be used for characterizing deeper test intervals within the aquifer.

Prior to developing a final detailed hydrologic test plan that identifies specific hydrologic test methods to be conducted, FH will discuss with Pacific Northwest National Laboratory (PNNL) the benefits of different test design options, well configurations, and well locations for performing characterization tests to maximize data quality. Data quality, however, may be constrained by existing test/site logistics (e.g., disposal of purgewater, presence or lack of monitoring wells, pump-and treat operational restrictions, etc.).

A1.3.7 Supplemental Data

The data resulting from implementation of this SAP may be supplemented by information derived from other groundwater investigations performed onsite. This supplemental information includes, but is not limited to, the following:

- Performing sampling and analysis activities required to monitor sites under RCRA
- Collecting water-level measurements
- Collecting pH, temperature, and conductivity readings
- Performing hydrologic testing and conducting DNAPL investigations
- Implementing quality assurance activities (e.g., Washington State Department of Health co-sampling)
- Possibly performing research activities.

The supplemental data may be used to help refine the conceptual site model and to provide information on contaminant movement through the vadose zone. Wells potentially providing supplemental information for the 200-ZP-1 network and the primary sampling purpose for each of these wells are presented in Appendix B of the RI/FS DQO summary report (FH 2003b).

A1.3.8 Dense Nonaqueous Phase Liquid Investigations

The presence or absence of DNAPLs in the 200-ZP-1 OU and its three-dimensional distribution within the OU is recognized as a data gap that needs to be filled to support the CERCLA RI/FS process. The DNAPL investigations in the vadose zone and groundwater in the vicinity of the 216-Z-9 Trench are currently being addressed by *Sampling and Analysis Plan for Investigation of Dense Nonaqueous Phase Liquid Carbon Tetrachloride at the 216-Z-9 Trench* (DOE-RL 2003). A separate SAP will be prepared to address the remainder of the DNAPL characterization strategy identified in Section 6.5 of *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (DOE-RL 2004). This DNAPL characterization data shall be available to support the CERCLA RI/FS project schedule identified in Figure 6-1 of the work plan.

A1.3.9 Sampling Design for Microscopic and Geochemical Analysis

A study of the geochemical process involved in the contaminant plume saturated zone requires as many as five, 2- to 5-kg (4.4- to 11.01-lb) aquifer sediment samples obtained from the near source, middle, and distal regions of the contaminated groundwater plume. These samples would be collected during drilling of proposed wells "C," "H," and 299-W15-46 (Table 5-2). The samples will be analyzed for the model input parameters described in Table A2-2. As described in Section 5.1.5 (main text of this work plan), these samples will also be tested using the analytical methods described in Table A2-1.

Using these samples, the following activities may also be performed to better characterize the behavior of transport mechanisms in the groundwater:

- Determination of retardation processes and sorbed/dissolved contaminant inventories in groundwater, and the kinetics of solid-liquid redistribution phenomena controlling migration and influencing potential remediation efficiency.

- A combination of microscopic contaminant characterization with advanced radiochemical, microscopic, and analytical techniques, and kinetic studies of desorption/dissolution rate will provide information necessary to assess the long-term behavior of contaminants in the vadose zone and contaminated groundwater at 200-ZP-1. The experimental measurements will be interpreted with a suite of geochemical and mass transport models that are maintained and/or were developed by PNNL.

A1.3.10 Preliminary Target Action Levels

Table A1-7 identifies the basis for establishing the preliminary target action level for each of the COCs. In the RI/FS DQO summary report (FH 2003b), preliminary target action levels were provided for two zones: the groundwater inside the core zone, and groundwater outside the core zone. Outside core zone, preliminary target action limits were chosen to reflect an unrestricted-use scenario. Typically, the preliminary target action limits outside the core zone were assumed to be primary or secondary drinking water limits, or *Washington Administrative Code* (WAC) 173-340-720(4) limits. Inside the core zone, it was assumed in general that if groundwater COC concentrations were more than 10 times the preliminary target action levels outside the core zone, remedial action may be considered. Subsequent to the DQO process, a more systematic and rigorous approach was agreed to between RL and EPA. It was determined that points of calculation would be established inside and outside of the core zone. Outside the core zone, the preliminary target action levels would be the lower of primary and secondary drinking water standards, or WAC 173-340-720(4) levels. If the natural background or the detection limit for any constituent were higher than the regulatory limits, the preliminary target action level was adjusted upward to reflect those considerations. Inside the core zone, the preliminary target action levels for a specific plume and COC would be a level predicted by modeling such that the preliminary target action levels would not exceed the levels provided in Table A1-7. The points of calculation that will be used when performing risk assessments include the Columbia River, Central Plateau boundary, four corners of the operable unit boundary, and center of the largest groundwater contamination plume (carbon tetrachloride), as well as the center of any other contaminant plumes that are outside the overlay of the carbon tetrachloride plum (5 µg/L isopleths). For example, a well may be selected from within the high concentration area of a contaminant plume and modeled to determine the level of remediation necessary to return groundwater in the area to the preliminary target action levels provided in Table A1-7.

The numerical values provided in Table A1-7 are important in order to obtain appropriate analytical support and to provide an initial level against which preliminary decisions can be made as to the importance of a given COC and potential remediation needs. The numerical values for the final regulatory action levels both inside and outside the core zone at the various points of calculation will be established in the feasibility study and the final Record of Decision (ROD) and will supersede the values in Table A1-7.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Volatile Organics – Units for Nonradiological COCs (µg/L)								
Acetone	—	—	800	—	20	800	CLARC	CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Benzene	5	—	0.795	—	5	5	CRDL	CLARC < MCL and CRDL > CLARC.
Carbon disulfide	—	—	800	—	5	800	CLARC	CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Carbon tetrachloride	5	—	0.337	—	3	3	CRDL	CRDL > CLARC. CERCLA COC in current groundwater well monitoring network.[f]
Chloroform	80	—	7.17	—	5	7.17	CLARC	CLARC < MCL and CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chlorobenzene	100	—	160	—	5	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL
Ethyl benzene	700	—	800	—	5	700	Primary MCL[e]	MCL < CLARC, and MCL > CRDL
Methylene chloride	5	—	5.83	—	1	5	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Methyl ethyl ketone	—	—	4,800	—	10	4,800	CLARC	CLARC > CRDL.
4-methyl-2-pentanone (hexone, MIBK)	—	—	640	—	10	640	CLARC	CLARC > CRDL.
N-butyl benzene	—	—	320	—	5	320	CLARC	CLARC > CRDL.
Cis 1,2-dichloroethylene	70	—	80	—	10	70	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Trans 1,2-dichloroethylene	100	—	160	—	10	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
1,2-dichloroethane (DCA)	5	—	0.481	—	5	5	CRDL	CLARC < MCL and CRDL > CLARC.
Toluene	1,000	—	1,600	—	5	1,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
1,1,1-trichloroethane (TCA)	200	—	7,200	—	5	200	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL[a]	CLARC 3.1 Groundwater Method B[f]	Background[b]	CRDL	Selected Limit[d]	Source[d]	Comments
Trichloroethylene (TCE)	5	—	3.98	—	5	5	CRDL	CLARC < MCL and CLARC < CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Tetrachloroethylene (PCE)	5	—	0.858	—	5	5	CRDL	CLARC < MCL and CLARC > CRDL.
Xylene (total)	10,000	—	16,000	—	10	10,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Semi-Volatile Organics – Units for Nonradiological COCs (µg/L)								
Cresols	—	—	80[g]	—	10	80	CLARC	CLARC > CRDL. CLARC based on p-cresol.
Kerosene	—	—	—	—	500	TBD[h]		No regulatory limits available.
Phenols (total)	—	—	—	—	10	TBD[h]		No regulatory limits available.
Metals – Units for Nonradiological COCs (µg/L)								
Antimony	6	--	6.4	—	10	10	CRDL	MCL < CLARC, but CRDL > MCL.
Arsenic	10[e]	—	0.0583	10	10	10	CRDL	CLARC < MCL, CRDL= Hanford background > CLARC. CERCLA COC in current groundwater well monitoring network.[f]
Cadmium	5	—	8	<10	5	5	Primary MCL[e]	MCL < CLARC, and MCL = CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chromium (total)	100[n]	—	24,000	<30	10	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chromium (hexavalent)	—	—	48[c]	—	10	48	CLARC	CLARC > CRDL. There is no drinking water MCL for hexavalent chromium.
Iron	—	300	--	86	50	300	Secondary MCL	MCL > CRDL. Secondary drinking water standard = 300 µg/L (http://www.epa.gov/safewater/mcl.html). See footnote m.
Lead	15	—	—	<5	10	15	Primary MCL[e]	MCL > CRDL. Drinking water treatment levels = 15 µg/L (http://www.epa.gov/safewater/mcl.html).
Lithium	—	—	—	—	25	TBD[h]		No regulatory limits available.
Magnesium	—	—	—	16,480	750	TBD[h]		No regulatory limits available.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Manganese	—	50	2,240	24.5	5	50	Secondary MCL	CLARC > CRDL. Secondary drinking water standard = 50 μg/L (http://www.epa.gov/safewater/mcl.html). See footnote m.
Mercury	2	—	4.8	<0.1	0.5	2	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Nickel	—	—	320	—	40	320	CLARC	CLARC > CRDL.
Selenium	50	—	80	—	10	50	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Silver	—	100	80	—	10	80	CLARC	CLARC > CRDL.
Uranium (total)	30	—	48	3.43	0.1	30	Primary MCL[e]	MCL < CLARC, and MCL > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Vanadium	—	—	112	15	50	112	CLARC	Noncarcinogen CLARC > CRDL.
Non-Metals – Units for Nonradiological COCs (μg/L)								
Ammonium	—	—	—	120	50	TBD[h]		No regulatory limits available.
Cyanide	200	—	320	—	5	200	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Fluoride	4,000	2,000	—	775	500	4,000	Primary MCL[e]	Primary MCL > background and CRDL. Secondary drinking water standard is unenforceable and other standards are available.
Nitrate	44,285	—	7,086	12,400	75	12,400	Background	Background > CLARC and CRDL.
Nitrate as nitrogen	10,000	—	1,600	2,800	17	2,800	Background	Background > CLARC and CRDL.
Nitrite	3,286	—	5,257	—	75	3,268	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Nitrite as nitrogen	1,000	—	1,600	—	17	1,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Phosphate	—	—	—	<1,000	500	TBD[h]		No regulatory limits available.
Radiological COCs – Beta Emitters – Units for Radiological COCs (pCi/L, unless otherwise noted)								
C-14	2,000[j]	—	—	—	200	2,000[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
I-129	1[j]	—	—	—	0.5	1[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL[a]	CLARC 3.1 Groundwater Method B[c]	Background[b]	CRDL	Selected Limit[d]	Source[d]	Comments
Se-79	4 mrem/yr[i]	—	—	—	30	4 mrem/yr[i]	Primary MCL[i]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Sr-90	8[j]	—	—	—	2	8[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Tc-99	900[j,k]	—	—	—	20	900[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
H-3	20,000[j]	—	—	—	400	20,000[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Radiological COCs – Alpha Emitters – Units for Radiological COCs (pCi/L)								
Np-237	15	—	—	—	1	15	Primary MCL	MCL > CRDL.
Pa-231	15	—	—	—	1	15	Primary MCL	MCL > CRDL.
Radiological COCs – Gamma Emitters – Units for Radiological COCs (pCi/L)								
Cs-137	60[j]	—	—	—	15	60[j]	MCL[j]	CERCLA COC in current groundwater well monitoring network.[f]

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC 3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Volatile Organics – Units for Nonradiological COCs (µg/L)								
Acetone	—	—	800	—	20	800	CLARC	CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Benzene	5	—	0.795	—	5	5	CRDL	CLARC < MCL and CRDL > CLARC.
Carbon disulfide	—	—	800	—	5	800	CLARC	CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Carbon tetrachloride	5	—	0.337	—	3	3	CRDL	CRDL > CLARC. CERCLA COC in current groundwater well monitoring network.[f]
Chloroform	80	—	7.17	—	5	7.17	CLARC	CLARC < MCL and CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chlorobenzene	100	—	160	—	5	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL
Ethyl benzene	700	—	800	—	5	700	Primary MCL[e]	MCL < CLARC, and MCL > CRDL
Methylene chloride	5	—	5.83	—	1	5	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Methyl ethyl ketone	—	—	4,800	—	10	4,800	CLARC	CLARC > CRDL.
4-methyl-2-pentanone (hexone, MIBK)	—	—	640	—	10	640	CLARC	CLARC > CRDL.
N-butyl benzene	—	—	320	—	5	320	CLARC	CLARC > CRDL.
Cis 1,2-dichloroethylene	70	—	80	—	10	70	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Trans 1,2-dichloroethylene	100	—	160	—	10	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
1,2-dichloroethane (DCA)	5	—	0.481	—	5	5	CRDL	CLARC < MCL and CRDL > CLARC.
Toluene	1,000	—	1,600	—	5	1,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
1,1,1-trichloroethane (TCA)	200	—	7,200	—	5	200	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC 3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Trichloroethylene (TCE)	5	—	3.98	—	5	5	CRDL	CLARC < MCL and CLARC < CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Tetrachloroethylene (PCE)	5	—	0.858	—	5	5	CRDL	CLARC < MCL and CLARC > CRDL.
Xylene (total)	10,000	—	16,000	—	10	10,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Semi-Volatile Organics – Units for Nonradiological COCs (µg/L)								
Cresols	—	—	80[g]	—	10	80	CLARC	CLARC > CRDL. CLARC based on p-cresol.
Kerosene	—	—	—	—	500	TBD[h]		No regulatory limits available.
Phenols (total)	—	—	—	—	10	TBD[h]		No regulatory limits available.
Metals – Units for Nonradiological COCs (µg/L)								
Antimony	6	—	6.4	—	10	10	CRDL	MCL < CLARC, but CRDL > MCL.
Arsenic	10[c]	—	0.0583	10	10	10	CRDL	CLARC < MCL, CRDL= Hanford background > CLARC. CERCLA COC in current groundwater well monitoring network.[f]
Cadmium	5	—	8	<10	5	5	Primary MCL[e]	MCL < CLARC, and MCL = CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chromium (total)	100[n]	—	24,000	<30	10	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chromium (hexavalent)	—	—	48[c]	—	10	48	CLARC	CLARC > CRDL. There is no drinking water MCL for hexavalent chromium.
Iron	—	300	—	86	50	300	Secondary MCL	MCL > CRDL. Secondary drinking water standard = 300 µg/L (http://www.epa.gov/safewater/mcl.html). See footnote m.
Lead	15	—	—	<5	10	15	Primary MCL[e]	MCL > CRDL. Drinking water treatment levels = 15 µg/L (http://www.epa.gov/safewater/mcl.html).
Lithium	—	—	—	—	25	TBD[h]		No regulatory limits available.
Magnesium	—	—	—	16,480	750	TBD[h]		No regulatory limits available.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC 3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Manganese	—	50	2,240	24.5	5	50	Secondary MCL	CLARC > CRDL. Secondary drinking water standard = 50 µg/L (http://www.epa.gov/safewater/mcl.html). See footnote m.
Mercury	2	—	4.8	<0.1	0.5	2	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Nickel	—	—	320	—	40	320	CLARC	CLARC > CRDL.
Selenium	50	—	80	—	10	50	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Silver	—	100	80	—	10	80	CLARC	CLARC > CRDL.
Uranium (total)	30	—	48	3.43	0.1	30	Primary MCL[e]	MCL < CLARC, and MCL > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Vanadium	—	—	112	15	50	112	CLARC	Noncarcinogen CLARC > CRDL.
Non-Metals – Units for Nonradiological COCs (µg/L)								
Ammonium	—	—	—	120	50	TBD[h]		No regulatory limits available.
Cyanide	200	—	320	—	5	200	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Fluoride	4,000	2,000	—	775	500	4,000	Primary MCL[e]	Primary MCL > Background and CRDL. Secondary drinking water standard is unenforceable and other standards are available.
Nitrate	44,285	—	7,086	12,400	75	12,400	Background	Background > CLARC and CRDL.
Nitrate as nitrogen	10,000	—	1,600	2,800	17	2,800	Background	Background > CLARC and CRDL.
Nitrite	3,286	—	5,257	—	75	3,268	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Nitrite as nitrogen	1,000	—	1,600	—	17	1,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Phosphate	—	—	—	<1,000	500	TBD[h]		No regulatory limits available.
Radiological COCs – Beta Emitters – Units for Radiological COCs (pCi/L, unless otherwise noted)								
C-14	2,000[j]	—	—	—	200	2,000[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
I-129	1[j]	—	—	—	0.5	1[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	GLARC 3.4 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Se-79	4 mrem/yr[i]	—	—	—	30	4 mrem/yr[i]	Primary MCL[i]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Sr-90	8[j]	—	—	—	2	8[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Tc-99	900[j,k]	—	—	—	20	900[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
H-3	20,000[j]	—	—	—	400	20,000[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Radiological COCs – Alpha Emitters – Units for Radiological COCs (pCi/L)								
Np-237	15	—	—	—	1	15	Primary MCL	MCL > CRDL.
Pa-231	15	—	—	—	1	15	Primary MCL	MCL > CRDL.
Radiological COCs – Gamma Emitters – Units for Radiological COCs (pCi/L)								
Cs-137	60[j]	—	—	—	15	60[j]	MCL[j]	CERCLA COC in current groundwater well monitoring network.[f]

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC 3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Volatile Organics – Units for Nonradiological COCs (µg/L)								
Acetone	—	—	800	—	20	800	CLARC	CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Benzene	5	—	0.795	—	5	5	CRDL	CLARC < MCL and CRDL > CLARC.
Carbon disulfide	—	—	800	—	5	800	CLARC	CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Carbon tetrachloride	5	—	0.337	—	3	3	CRDL	CRDL > CLARC. CERCLA COC in current groundwater well monitoring network.[f]
Chloroform	80	—	7.17	—	5	7.17	CLARC	CLARC < MCL and CLARC > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chlorobenzene	100	—	160	—	5	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL
Ethyl benzene	700	—	800	—	5	700	Primary MCL[e]	MCL < CLARC, and MCL > CRDL
Methylene chloride	5	—	5.83	—	1	5	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Methyl ethyl ketone	—	—	4,800	—	10	4,800	CLARC	CLARC > CRDL.
4-methyl-2-pentanone (hexone, MIBK)	—	—	640	—	10	640	CLARC	CLARC > CRDL.
N-butyl benzene	—	—	320	—	5	320	CLARC	CLARC > CRDL.
Cis 1,2-dichloroethylene	70	—	80	—	10	70	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Trans 1,2-dichloroethylene	100	—	160	—	10	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
1,2-dichloroethane (DCA)	5	—	0.481	—	5	5	CRDL	CLARC < MCL and CRDL > CLARC.
Toluene	1,000	—	1,600	—	5	1,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
1,1,1-trichloroethane (TCA)	200	—	7,200	—	5	200	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL[a]	CLARC 3.1 Groundwater Method B[b]	Background[c]	CRDL	Selected Limit[d]	Source[d]	Comments
Trichloroethylene (TCE)	5	—	3.98	—	5	5	CRDL	CLARC < MCL and CLARC < CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Tetrachloroethylene (PCE)	5	—	0.858	—	5	5	CRDL	CLARC < MCL and CLARC > CRDL.
Xylene (total)	10,000	—	16,000	—	10	10,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Semi-Volatile Organics – Units for Nonradiological COCs (µg/L)								
Cresols	—	—	80[g]	—	10	80	CLARC	CLARC > CRDL. CLARC based on p-cresol.
Kerosene	—	—	—	—	500	TBD[h]		No regulatory limits available.
Phenols (total)	—	—	—	—	10	TBD[h]		No regulatory limits available.
Metals – Units for Nonradiological COCs (µg/L)								
Antimony	6	—	6.4	—	10	10	CRDL	MCL < CLARC, but CRDL > MCL.
Arsenic	10[e]	—	0.0583	10	10	10	CRDL	CLARC < MCL, CRDL= Hanford background > CLARC. CERCLA COC in current groundwater well monitoring network.[f]
Cadmium	5	—	8	<10	5	5	Primary MCL[e]	MCL < CLARC, and MCL = CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chromium (total)	100[n]	—	24,000	<30	10	100	Primary MCL[e]	MCL < CLARC, and MCL > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Chromium (hexavalent)	—	—	48[c]	—	10	48	CLARC	CLARC > CRDL. There is no drinking water MCL for hexavalent chromium.
Iron	—	300	—	86	50	300	Secondary MCL	MCL > CRDL. Secondary drinking water standard = 300 µg/L (http://www.epa.gov/safewater/mcl.html). See footnote m.
Lead	15	—	—	<5	10	15	Primary MCL[e]	MCL > CRDL. Drinking water treatment levels = 15 µg/L (http://www.epa.gov/safewater/mcl.html).
Lithium	—	—	—	—	25	TBD[h]		No regulatory limits available.
Magnesium	—	—	—	16,480	750	TBD[h]		No regulatory limits available.

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC 3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	Comments
Manganese	—	50	2,240	24.5	5	50	Secondary MCL	CLARC > CRDL. Secondary drinking water standard = 50 µg/L (http://www.epa.gov/ safewater/mcl.html). See footnote m.
Mercury	2	—	4.8	<0.1	0.5	2	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Nickel	—	—	320	—	40	320	CLARC	CLARC > CRDL.
Selenium	50	—	80	—	10	50	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Silver	—	100	80	—	10	80	CLARC	CLARC > CRDL.
Uranium (total)	30	—	48	3.43	0.1	30	Primary MCL[e]	MCL < CLARC, and MCL > CRDL. CERCLA COC in current groundwater well monitoring network.[f]
Vanadium	—	—	112	15	50	112	CLARC	Noncarcinogen CLARC > CRDL.
Non-Metals – Units for Nonradiological COCs (µg/L)								
Ammonium	—	—	—	120	50	TBD[h]		No regulatory limits available.
Cyanide	200	—	320	—	5	200	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Fluoride	4,000	2,000	—	775	500	4,000	Primary MCL[e]	Primary MCL > background and CRDL . Secondary drinking water standard is unenforceable and other standards are available.
Nitrate	44,285	—	7,086	12,400	75	12,400	Background	Background > CLARC and CRDL.
Nitrate as nitrogen	10,000	—	1,600	2,800	17	2,800	Background	Background > CLARC and CRDL.
Nitrite	3,286	—	5,257	—	75	3,268	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Nitrite as nitrogen	1,000	—	1,600	—	17	1,000	Primary MCL[e]	MCL < CLARC, and MCL > CRDL.
Phosphate	—	—	—	<1,000	500	TBD[h]		No regulatory limits available.
Radiological COCs – Beta Emitters – Units for Radiological COCs (pCi/L, unless otherwise noted)								
C-14	2,000[j]	—	—	—	200	2,000[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
I-129	1[j]	—	—	—	0.5	1[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. *CERCLA COC in current* groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL[a]	CLARC 3.1 Groundwater Method B[a]	Background[a]	CRDL	Selected Limit[b]	Source[b]	Comments
Se-79	4 mrem/yr[i]	—	—	—	30	4 mrem/yr[i]	Primary MCL[i]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Sr-90	8[j]	—	—	—	2	8[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Tc-99	900[j,k]	—	—	—	20	900[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. CERCLA COC in current groundwater well monitoring network.[f] From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
H-3	20,000[j]	—	—	—	400	20,000[j]	Primary MCL[j]	MCL > CRDL. MCL based on 4 mrem/yr. From http://www.epa.gov/safewater/mcl.html (EPA et al. 1997).
Radiological COCs – Alpha Emitters – Units for Radiological COCs (pCi/L)								
Np-237	15	—	—	—	1	15	Primary MCL	MCL > CRDL.
Pa-231	15	—	—	—	1	15	Primary MCL	MCL > CRDL.
Radiological COCs – Gamma Emitters – Units for Radiological COCs (pCi/L)								
Cs-137	60[j]	—	—	—	15	60[j]	MCL[j]	CERCLA COC in current groundwater well monitoring network.[f]

Table A1-7. Preliminary Target Action Levels and Basis for Groundwater Contaminants of Concern. (13 sheets)

COC	Primary MCL	Secondary MCL	CLARC 3.1 Groundwater Method B	Background	CRDL	Selected Limit	Source	[illegible]	Comments

[a] Primary MCLs were used where available and are assumed unless noted; secondary MCLs are noted in the comments column.

[b] *Hanford Site Groundwater Background*, DOE/RL-92-23 (DOE-RL 1992a).

[c] WAC 173-340-740(4) groundwater Method B values from Ecology's *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation (CLARC III)*, Section 3.1 tables (Ecology 2001).

[d] The selected limit is the lower of the MCL or CLARC values with the following exception: if the background or CRDL is higher, the higher of these is selected. If the CLARC tables allowed a choice between carcinogenic and noncarcinogenic values for groundwater, the lower was chosen. In some cases, no regulatory limit is available.

[e] Target action level represents primary MCL (from web site http://www.epa.gov/safewater/mcl.html).

[f] From *Data Quality Objectives Summary Report for Establishing a RCCRA/CERCLA/AEA Integrated 200 West and 200 East Groundwater Monitoring Network* (FH 2003a).

[g] It is not known which of the cresols might be found; therefore, target action levels were based on p-cresol and are a factor of 10 lower than the other cresols.

[h] These nonradiological COCs will be sampled and analyzed in FY04 and FY06 for wells identified in Section A3.2.1 of this work plan. If these COCs are not found during these sampling events, they will not be considered again in this CERCLA process. If these COCs are detected at levels deemed significant (greater than the CRDLs in Table A2-1), then a target action level may be established with RL and EPA concurrence.

[i] This radiological COC will be sampled and analyzed in FY04 and FY06 for wells identified in Section A3.2.1 of this work plan. If these COCs are not found during these sampling events, they will not be considered again in this CERCLA process. A calculation has not been performed to establish a target action level (pCi/L) from the drinking water regulatory requirement of 4 mrem/yr for these COCs. If these COCs are detected at levels deemed significant (greater than the *CRDLs in Table A2-1*), *then a target action level may* be established with RL and EPA concurrence to ensure that the hypothetical dose from these radionuclides is less than 4 mrem/yr outside the core zone.

[j] Target action level based on the estimated groundwater concentration that would result 4 mrem/year (MCL) to the whole body or an organ if the groundwater water were used as drinking water (DOE-RL 2002, Table 2-3).

[k] Technetium-99 remedial target action levels defined in *Record of Decision for the 200-UP-1 Interim Remedial Measure* (EPA et al. 1997).

[m] In some instances, drilling through basalt for the well may contribute to contamination of the well water with iron and manganese.

[n] *Total chromium based on chromium III and VI values.*

AEA = *Atomic Energy Act of 1954*
CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CLARC = *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation*
COC = contaminant of concern
CRDL = contract-required detection limit
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
FY = fiscal year
MCL = maximum contaminant level
RCRA = *Resource Conservation and Recovery Act of 1976*
RL = U.S. Department of Energy, Richland Operations Office
TBD = to be determined
WAC = *Washington Administrative Code*

A2.0 QUALITY ASSURANCE PROJECT PLAN

This section identifies the individuals or organizations participating in the project and discusses specific roles and responsibilities. The quality objectives for measurement data and the special training requirements for staff performing the work are also documented.

A2.1 PROJECT MANAGEMENT

The following subsections address the basic areas of project management and will ensure that the project has a defined goal, the participants understand the goal and the approach to be used, and the planned outputs have been appropriately documented.

A2.1.1 Project/Task Organization

Fluor Hanford, Inc. (FH), or its approved subcontractor, will be responsible for collecting, packaging, and shipping groundwater samples to the laboratory. FH will select a laboratory to perform the analyses; the laboratory selected must conform to Hanford Site laboratory procedures, or their equivalent as approved by RL, EPA, and the Washington State Department of Ecology (Ecology). FH is responsible for managing all interfaces among subcontractors involved in executing the work described in this work plan and SAP.

A2.1.2 Quality Objectives and Criteria for Measurement Data

The detection limits and the precision and accuracy requirements for each analysis to be performed are summarized Table A2-1. Table A2-2 lists the geological, physical, hydraulic transport, and geochemical inputs and methods.

Procedures from either FH or its subcontractor, Duratek Federal Services Northwest (DFSNW), will be used. Should a different subcontractor be selected, equivalent and reviewed procedures will be used. This applied to all FH or DFSNW procedures identified in this SAP.

A2.1.3 Special Training Requirements and Certification

Training or certification requirements for sampling personnel shall be in accordance with the requirements specified in the *Hanford Analytical Services Quality Assurance Requirements Document* (HASQARD), Vol. 1, "Administrative Requirements" (DOE-RL 1998).

Field personnel will typically have completed the following training before starting work:

- Occupational Safety and Health Administration 40-Hour Hazardous Waste Worker Training
- 8-Hour Hazardous Waste Worker Refresher Training (as required)
- Radiation Worker II Training
- Hanford General Employee Training.

Table A2-1. Analytical Performance Requirements for Contaminant of Concern Analysis. (3 sheets)

Type of COC	COCs	Survey or Analytical Method[a]	CRDL[b] µg/L	Precision Required	Accuracy Required
Nonradiological COCs					
Volatile organics	Acetone	SW-846, Method 8260[b]	20	[e]	[e]
	Benzene		5[f]	[e]	[e]
	Carbon disulfide		5	[e]	[e]
	Carbon tetrachloride		3[f]	[e]	[e]
	Chloroform		5[f]	[e]	[e]
	Chlorobenzene		5	[e]	[e]
	Ethyl benzene		5	[e]	[e]
	Methylene chloride		1	[e]	[e]
	Methyl ethyl ketone		10	[e]	[e]
	4-methyl-2-pentanone (hexone, MIBK)		10	[e]	[e]
	N-butyl benzene		5	[e]	[e]
	Cis-1,2-dichloroethylene		10	[e]	[e]
	Trans-1,2-dichloroethylene		10	[e]	[e]
	1,2-dichloroethane (DCA)		5[f]	[e]	[e]
	Toluene		5	[e]	[e]
	1,1,1-trichloroethane (TCA)		5	[e]	[e]
	Trichloroethylene (TCE)		5[f]	[e]	[e]
	Tetrachloroethylene (PCE)		5[f]	[e]	[e]
	Xylene (total)		10	[e]	[e]
Semi-volatile organics	Cresols	8270[c]	10	[e]	[e]
	Kerosene	WTPH-D (extended to kerosene range)	500	[e]	[e]
	Phenol	8270	10	[e]	[e]
	Phenols (total)	8270[c]	10	[e]	[e]
Metals	Antimony	6010-B or 200.8	10	±25%	±25%
	Arsenic	6010-B or 200.8	10[f]	±25%	±25%
	Cadmium	6010-B or 200.8	5[f]	±25%	±25%
	Chromium (total)	6010-B or 200.8	10	±25%	±25%
	Chromium (hexavalent)	7196A	10	±25%	±25%
	Iron	6010-B or 200.8	50[g]	±25%	±25%
	Lead	6010-B (trace) or 200.8	10[f]	±25%	±25%

Table A2-1. Analytical Performance Requirements for Contaminant of Concern Analysis. (3 sheets)

Type of COC	COCs	Survey or Analytical Method[a]	CRDL[b] µg/L	Precision Required	Accuracy Required
	Lithium	6010-B or 200.8	25[g]	±25%	±25%
	Magnesium	6010-B or 200.8	750[g]	±25%	±25%
	Manganese	6010-B or 200.8	5[g]	±25%	±25%
	Mercury	7470 or 200.8	0.5	±25%	±25%
	Nickel	6010-B or 200.8	40	±25%	±25%
	Selenium	6010-B (trace) or 200.8	5	±25%	±25%
	Silver	6010-B or 200.8	20	±25%	±25%
	Vanadium	6010-B or 200.8	50	±25%	±25%
Non-metals	Ammonium	300.7 or 350.1[d]	50	±25%	±25%
	Cyanide	9010 or 335.2[d]	5	±25%	±25%
	Fluoride	300.0[d]	500	±25%	±25%
	Nitrite	300.0[d]	75	±25%	±25%
	Nitrate	300.0[d]	75	±25%	±25%
	Phosphorus and phosphate (must digest to include organo-phosphates)	365.1, 365.2, or 365.3	50 µg P/L	±25%	±25%
Type of COC	**COCs**	**Methods**	**MDC pCi/L (unless otherwise noted)**	**Precision**	**Accuracy**
		Radiological COCs			
Beta emitters	C-14	Liquid scintillation	200	±30%	70-130%
	I-129	Low-energy photon spectroscopy	0.5[f]	±30%	70-130%
	Se-79	Liquid scintillation	30	±30%	70-130%
	Sr-90	Gas proportional counting	2	±30%	70-130%
	Tc-99	Liquid scintillation	20	±30%	70-130%
	H-3	Liquid scintillation	400	±30%	70-130%

Table A2-1. Analytical Performance Requirements
for Contaminant of Concern Analysis. (3 sheets)

Type of COC	COCs	Methods	MDC[b] pCi/L (unless otherwise noted)	Precision	Accuracy
Alpha emitters	Np-237	Alpha spectroscopy	1	±30%	70-130%
	Pa-231	Alpha spectroscopy	1	±30%	70-130%
	Uranium (total)	Kinetic phosphorescence or 200.8	0.1 µg/L	±30%	70-130%
Gamma emitters	Cs-137	Gamma spectroscopy	15	±30%	80-120%

[a] Analytical method selection is based on available methods by laboratories currently contracted to the Hanford Site. Equivalent methods may be substituted in future sampling and analysis plans or other documents. Four-digit methods are from EPA's SW-846 (EPA 1997); other methods referenced to source.
[b] Typical CRDL or MDC based on current Hanford laboratory contracts. Detection limits in subsequent documents may differ depending on method selection and the contract laboratory. Units are µg/L for nonradiological COCs and pCi/L for radiological COCs (unless otherwise noted).
[c] Precision and accuracy in accordance with cited procedure.
[d] Method from *Standard Methods for Examination of Water and Wastewater* (Eaton et al. 1995).
[e] Specific methods vary from laboratory to laboratory.
[f] If the CRDL is at, very near (within 1 to 2 ppb), or above the preliminary target action levels, an attempt will be made to use larger sample volumes to allow decreased reporting limits.
[g] These are not CRDLs and are project-specific.

COC = contaminant of concern
CRDL = contract-required detection limit
EPA = U.S. Environmental Protection Agency
MDC = minimum detectable concentration
ppb = parts per billion

Table A2-2. Saturated Zone Properties for Modeling Inputs, Remedial Action Alternative Evaluation, and Long-Term Monitoring of Groundwater. (2 sheets)

Property	Parameter	Method	CRDL	Precision Required	Accuracy Required
Aquifer Sediments					
Physical/ geological	Particle size distribution (by dry sieve, wet sieve, and hydrometer methods)	ASTM D422	N/A	N/A	N/A
	Calcium carbonate content	ASTM D4373	N/A	N/A	N/A
	Borehole geophysics (neutron probe, natural gamma, spectral gamma, and gamma-gamma density[b])	[a]	N/A	N/A	N/A
	Mineralogy	XRD	N/A	N/A	N/A
	Bulk density	ASTM D2937	N/A	N/A	N/A
	Lithology	Geologist description	N/A	N/A	N/A
Hydraulic and transport	Effective porosity	Field and laboratory measurement			
	Bulk density	ASTM D2937	N/A	N/A	N/A
	Total porosity	[a]	N/A	N/A	N/A
Geochemical	Major cations (e.g., sodium and calcium)	ASTM D4327	N/A	N/A	N/A
	Cation exchange capacity	Routson et al. (1973)	N/A	N/A	N/A
	TOC	415.1[c]	N/A	±25%	±25%
	K_d (carbon tetrachloride)	ASTM 3987	N/A	N/A	N/A
	TIC	415.1M[c]	25,000 µg C/kg sample	±25%	±25%
	pH	9045[d]	0.1 pH unit	±0.1 pH unit	±0.1 pH unit
Water					
Hydraulic and transport	Hydraulic gradient	Field measurement	N/A	N/A	N/A
	Slug test, slug interference test, constant rate discharge test, or tracer test	Field test	N/A	N/A	N/A
	Water production flow rate	Well development	N/A	N/A	N/A
	Water-level changes (drawdown)	Well development	N/A	N/A	N/A
	Groundwater pumping performance	Well development	N/A	N/A	N/A
	Dispersivity	Field tracer measurement	N/A	N/A	N/A

Table A2-2. Saturated Zone Properties for Modeling Inputs, Remedial Action Alternative Evaluation, and Long-Term Monitoring of Groundwater. (2 sheets)

Property	Parameter	Method	CRDL	Precision Required	Accuracy Required
Geochemical	Major cations (e.g., sodium and calcium)	ASTM D4327	N/A	N/A	N/A
	Cation exchange capacity	Routson et al. (1973)	N/A	N/A	N/A
	K_d (e.g., carbon tetrachloride)	ASTM 3987	N/A	N/A	N/A
	Specific conductivity	Field screening	N/A	N/A	N/A
	TOC	415.1[c]	1,000 µg/L	±25%	±25%
	TIC	415.1M[c]	1,000 µg/L	±25%	±25%
	pH	9045[d]	0.1 pH unit	±0.1 pH unit	±0.1 pH unit
	Temperature	Field screening	N/A	± 1°C	1°C
	Alkalinity	310.1[c] or 310.2[c]	10 mg/L as CO_3	±20%	±25%
	Dissolved oxygen	Field screening	N/A	0.1 mg/L	±1%
	Turbidity	Field screening	<5 NTU	N/A[e]	N/A[e]

[a] Method will be defined by technical support prior to implementation.
[b] If gamma-gamma density probe is not available at the time of logging, proceed running only natural and neutron-induced capture gamma-ray spectroscopy.
[c] Method from *Standard Methods for Examination of Water and Wastewater* (Eaton et al. 1995).
[d] Method from U.S. Environmental Protection Agency's SW-846 (EPA 1997).
[e] Requirements are "Yes/No" above or below 5 NTU; precision and accuracy do not apply.
ASTM = American Society for Testing and Materials
CRDL = contract-required detection limit
K_d = distribution coefficient
N/A = not applicable
NTU = nephelometric turbidity unit
TIC = tentatively identified compound
TOC = total organic carbon
XRD = x-ray diffraction

A2.1.4 Documentation and Records

Field sampling documentation will be in accordance with HASQARD, Vol. 2, "Sampling Technical Requirements" (DOE-RL 1998), and shall be kept in accordance with DFSNW-SSPM-001, *Sampling Services Procedure Manual* (or equivalent), including the following procedures:

- Procedure 1-1, "Chain of Custody/Sample Analysis Request"
- Procedure 1-5, "Logbooks."

Laboratory analytical documentation will be in accordance with the *Statement of Work for Environmental and Waste Characterization Analytical Services* (RFS 1999) for groundwater sampling. Overall project documentation will be in accordance with FH procedures standards-based management system.

A2.2 DATA/MEASUREMENT ACQUISITION

The following subsections present the requirements for sampling methods, sample handling and custody, analytical methods, and field and laboratory quality control (QC). The requirements for instrument calibration and maintenance, supply inspections, and data management are also addressed.

A2.2.1 Sampling Methods Requirements

The procedures to be implemented in the field should be in accordance with those outlined in HASQARD, Vol. 2, "Sampling Technical Requirements" (DOE-RL 1998), and/or DFSNW-SSPM-001 (or equivalent), as listed in Section A3.4 of this SAP.

A2.2.2 Sampling Identification

A sample and data-tracking database will be used to track the samples from the point of collection through the laboratory analysis process. The Hanford Environmental Information System (HEIS) database is the repository for laboratory analytical results. The HEIS sample numbers will be issued to the sampling organization for this project. The HEIS numbers are to be carried through the laboratory data-tracking system.

A2.2.3 Sample Handling, Shipping, and Custody Requirements

All sample handling, shipping, and custody requirements will be performed in accordance with DFSNW-SSPM-001, Procedure 2-6, "Sample Packaging and Shipping," and Procedure 1-1, "Chain of Custody/Sample Analysis Request" (or equivalent).

A2.2.4 Analytical Methods Requirements

Analytical parameters and methods are listed in Table A2-1. Laboratory-specific standard operating procedures for analytical methods are described in HASQARD, Vol. 4, "Laboratory Technical Requirements" (DOE-RL 1998).

A2.2.5 Quality Control Requirements

The QC procedures described in HASQARD, Vol. 2, "Sampling Technical Requirements," and Vol. 3, "Field Analytical Technical Requirements" (DOE-RL 1998), must be followed in the field and laboratory to ensure that reliable data are obtained. When performing this field sampling effort, care should be taken to prevent the cross-contamination of sampling equipment, sample bottles, and other equipment that could compromise sample integrity.

Table A2-3 lists the field QC requirements for sampling. If only disposable equipment is used or equipment is dedicated to a particular well, then an equipment rinsate blank is not required. If no volatile organic compound samples are collected, then a field transfer blank is not required.

Laboratory QC sample requirements are specified in the laboratory *Statement of Work for Environmental and Waste Characterization Analytical Services* (RFS 1999).

Table A2-3. Field Quality Control Requirements.

Sample Type	Frequency	Purpose
Duplicate	5% (1 sample in 20)	To check the precision of the laboratory analyses.
Equipment rinsate	One per 10 well trips	To check the effectiveness of the decontamination process.
Field transfer blank	One per day when volatile organics are sampled	To check for contamination during transport.

A2.2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

All onsite environmental instruments shall be tested, inspected, and maintained in accordance with DFSNW-SSPM-001, Procedure 6-1, "Control of Monitoring Instruments" (or equivalent). The results from all testing, inspection, and maintenance activities shall be recorded in a bound logbook in accordance with procedures outlined in DFSNW-SSPM-001, Procedure 1-5, "Logbooks."

A2.2.7 Instrument Calibration and Frequency

All onsite environmental instruments shall be calibrated in accordance with DFSNW-SSPM-001, Procedure 6-1, "Control of Monitoring Instruments" (or equivalent). The results from all instrument calibration activities shall be recorded in a bound logbook in accordance with procedures outlined in DFSNW-SSPM-001, Procedure 1-5, "Logbooks." Tags will be attached to all field screening and onsite analytical instruments, noting the date when the instrument was last calibrated and the calibration expiration date.

A2.2.8 Inspection/Acceptance Requirements for Supplies and Consumables

All subject activities shall meet requirements of HASQARD, Vol. 1, "Administrative Requirements" (DOE-RL 1998). The lot number from the manufacturer-certified, pre-cleaned sample containers shall be recorded in the sampler's logbook.

A2.2.9 Data Management

Data resulting from the implementation of this SAP will be stored in the HEIS database. All reports and supporting analytical data packages will be subject to final technical review by qualified reviewers before submittal to the regulatory agencies or inclusion in reports or technical memoranda. Electronic data access, when appropriate, shall be through computerized databases (e.g., HEIS). Where electronic data are not available, hard copies will be provided in accordance with Section 9.6 of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et. al. 2003).

A2.2.10 Sample Preservation, Containers, and Holding Times

Sample preservation, container, and holding time requirements will be prepared for specific sample events as specified on the sampling authorization forms and chain-of-custody forms in accordance with the requirements specified in RFS (1999) and the specific analytical method.

A2.2.11 Field Documentation

Field documentation shall be kept in accordance with HASQARD, Vol. 2, "Sampling Technical Requirements" (DOE-RL 1998), and DFSNW-SSPM-001 (or equivalent), including the following procedures:

- Procedure 1-1, "Chain of Custody/Sample Analysis Request"
- Procedure 1-5, "Logbooks."

A2.3 ASSESSMENT/OVERSIGHT

A2.3.1 Assessments and Response Action

The FH Compliance and Quality Programs group may conduct random surveillance and assessments to verify compliance with the requirements outlined in this SAP, project work packages, the project quality management plan, procedures, and regulatory requirements.

Deficiencies identified during these assessments shall be reported to the FH 200 Area Task Lead. When appropriate, corrective actions will be taken by the project engineer in accordance with HASQARD, Vol. 1, Section 4.0 (DOE-RL 1998), to minimize recurrence.

A2.3.2 Reports to Management

Management shall be made aware of all deficiencies identified by self-assessments. Identified deficiencies shall be reported to the FH 200 Area Task Lead.

A2.4 DATA REVIEW, VERIFICATION, VALIDATION, AND USABILITY REQUIREMENTS

A2.4.1 Data Verification and Usability Methods

Data review and verification are performed by the laboratory to confirm that sampling and chain-of-custody documentation are complete. Documentation includes tying sample numbers to specific sampling location, reviewing sample collection, indicating the preparation and analysis dates to assess meeting required holding times, and reviewing QC to determine whether analyses met the data quality requirements specified in this SAP.

All data verification and usability assessments shall be performed in accordance with HASQARD, Vol. 4, "Laboratory Technical Requirements" (DOE-RL 1998).

A2.4.2 Data Validation

Data validation is performed either by an independent third party not involved in sampling, analysis, or assessment; or by the Waste Disposal/Groundwater Remediation Projects; or by PNNL using the procedures cited in the next paragraph, or equivalent. *Data Validation Procedure for Chemical Analysis* (BHI 2000a) for chemical methods and *Data Validation Procedure for Radiochemical Analysis* (BHI 2000b) for radiochemical methods will be used to perform validation. Five percent of the results will undergo Level C validation, as defined by these validation procedures.

A2.4.3 Data Quality Assessment

Data quality will be assessed based on trends of concentration in wells over time. As appropriate, the data quality assessment may include the statistical approaches identified in WAC 173-340-720(4) for groundwater monitoring.

A3.0 FIELD SAMPLING PLAN

A3.1 SAMPLING OBJECTIVES

The objective of the field sampling plan is to clearly identify project sampling and analysis activities. The field sampling plan uses the sampling design identified during the DQO process and presents the design primarily using figures and tables whenever possible to identify sampling locations, the total number of samples to be collected, sampling procedures to be implemented, analyses to be performed, and sample bottle requirements.

A3.2 SAMPLING LOCATIONS AND FREQUENCY

A3.2.1 Enhanced Groundwater Monitoring Well Network

Of the 71 wells identified in Table A3-2 for monitoring the 200-ZP-1 OU, 63 wells currently exist and 8 are new wells to be installed. As shown on the plate map presented in Appendix B, the 63 existing wells are relatively evenly distributed within the boundaries of the COC plumes, with a tighter concentration of wells around the 2,000 μg/L carbon tetrachloride contour.

The eight new wells are positioned at locations that have been identified as data gaps (FH 2003a, 2003b). New wells "C," "D," "E," and "F" are proposed to be installed to refine the perimeter of the 2,000 μg/L carbon tetrachloride contour. New well "G" is proposed to be installed to refine the eastern portion of the 5 μg/L carbon tetrachloride contour. New well "H" is proposed to be installed west of T Plant to help define the spreading of the TCE, nitrate, tritium, uranium, and iodine-129 plumes, as well as to provide additional vertical distribution data (i.e., physical, geological, hydraulic, chemical, and geochemical properties) for this region of the OU. New well "I" is proposed to be installed as an upgradient monitoring well for the 200-ZP-1 OU. New well "T" is proposed to be installed due north of T Plant to define the northern edge of the nitrate, carbon tetrachloride, and tritium plume. Table A3-1 presents the proposed priority in which the new 200-ZP-1 wells are currently planned to be installed.

To assist in defining the three-dimensional distribution of COCs within the unconfined aquifer, approximately five depth-discrete groundwater and soil samples collected from new wells "C," "H," and 299-W15-46 (described in Section A1.3.5) shall be tested using the analytical methods described in Tables A2-1 and A2-2. These depth-discrete groundwater and soil samples shall be approximately evenly spaced between the top of the water table and the top of the Ringold Lower Mud Unit. New wells "C" and "H" will be drilled to the top of the Ringold Lower Mud Unit, approximately 36.6 to 61 m (120 to 200 ft) below the top of the unconfined aquifer; new well 299-W15-46 will be drilled through the Ringold Lower Mud Unit to basalt. One additional groundwater sample shall be collected from this interval.

Table A3-1. Priority for Installation of New Wells at the 200-ZP-1 Operable Unit.

Priority	New Well Name
1 (highest)	C
2	D
3	E
4	F
5	G
6	H
7	I
8 (lowest)	T

In addition, wells "D," "E," "F," "G," "I," and "T" (shown on the plate map in Appendix B) will be drilled 36.6 m (120 ft) below the water table, and a series of depth-discrete groundwater samples will be collected beyond the samples indicated in Table A3-2. These depth-discrete samples will be collected at approximately 9.1-m (30-ft) intervals, for a total of four samples. These samples shall be analyzed for carbon tetrachloride, TCE, chloroform, and PCE. These four COCs have been selected as indicator COCs that will provide insight into the three-dimensional distribution of contaminants within the aquifer.

Wells will be completed to screen the upper portion of the aquifer for COC analysis unless the highest concentration of contaminants is found at a deeper interval. In the latter case, RL and EPA will be consulted regarding the interval to be screened. The data obtained from these wells will allow more accurate modeling of plume movement and knowledge of the extent of vertical COC distribution.

Table A3-2 identifies the currently proposed, routinely sampled monitoring wells and their specific analyses and sampling frequency determined as a result of the data evaluation and other considerations discussed in the RI/FS DQO summary report (FH 2003b). Newly installed wells and replacement wells are to be sampled quarterly the first year after installation, semi-annually the second year after installation, then annually from that point on. Biennial sampling is used for perimeter wells that have shown stable concentrations for several years. If a well begins to show stable concentrations, the sampling frequency may decrease. Conversely, if irregular or increasing trends appear, the sampling frequency may increase accordingly.

The QC sampling requirements for these samples are listed in Table A2-3. Samples will be collected and managed in accordance with the procedures listed in Sections A3.4 and A3.5 of this SAP. All groundwater samples for metals analysis (i.e., chromium, arsenic, and cadmium) will be passed through a 0.45-micron filter prior to collection.

Changes to the monitoring network based on monitoring wells being taken out of service require approval from RL and the applicable regulatory agencies. This approval can be documented in meeting minutes.

Table A3-2. Routine Sampling and Analysis Requirements for the 200-ZP-1 Operable Unit Groundwater Monitoring Well Network. (5 sheets)

Well Number	Sampling Frequency	Onsite			Offsite								
		Carbon Tetrachloride	Chloroform	TCE	Tc-99	Uranium	I-129	Tritium	Chromium (Total)	Arsenic	Cadmium	Nitrate	Other
LLWMA-13[9] (New Well)	Quarterly	X		X			X	X			X	X	
299-W6-10	Annual	X		X		X	X	X			X	X	
299-W7-4[7]	Annual	X		X								X	
LLWMA-17[9] (New Well)	Quarterly	X		X				X	X			X	Antimony, iron
LLWMA-5[9] (New Well)	Quarterly	X		X				X				X	
299-W7-12[5]	Biennial	X						X				X	
299-W8-1[4]	Biennial	X						X				X	
299-W10-1	Annual	X	X	X				X	X	X		X	
299-W10-4[7]	Semi-annual	X	X	X	X		X	X	X	X		X	Fluoride
299-W10-5	Annual	X	X	X	X			X	X		X	X	VOC[3]
299-W10-13[5]	Biennial	X		X								X	
LLWMA-8[9] (New Well)	Quarterly	X		X							X	X	
299-W10-20[5]	Biennial	X	X	X								X	
299-W10-21	Annual	X	X	X				X			X	X	
299-W10-22	Semi-annual	X		X	X	X	X	X	X			X	
299-W10-23[7]	Annual	X	X	X	X	X	X	X	X	X	X	X	Fluoride

Table A3-2. Routine Sampling and Analysis Requirements for the 200-ZP-1 Operable Unit Groundwater Monitoring Well Network. (5 sheets)

Well Number	Sampling Frequency	Onsite			Offsite								
		Carbon Tetrachloride	Chloroform	TCE	Tc-99	Uranium	I-129	Tritium	Chromium (Total)	Arsenic	Cadmium	Nitrate	Other
299-W11-3	Semi-annual	X		X		X	X	X				X	
299-W11-6	Semi-annual	X		X		X	X					X	
299-W11-7	Annual	X	X	X	X	X	X		X	X	X	X	Fluoride
299-W11-10	Semi-annual	X	X									X	
299-W11-13	Semi-annual	X	X	X	X		X	X	X	X	X	X	
299-W11-14[7]	Semi-annual	X	X	X		X	X	X				X	Fluoride
299-W11-18	Annual	X	X	X	X	X	X	X	X		X	X	VOC[3], fluoride
299-W11-37	Semi-annual	X		X		X	X	X				X	
299-W12-1	Annual	X					X	X				X	
299-W14-14	Annual	X	X	X	X		X	X	X		X	X	Fluoride
299-W14-16	Annual	X		X	X		X	X	X			X	
299-W15-1	Semi-annual	X	X	X								X	
299-W15-2	Annual	X	X	X	X							X	
299-W15-7	Semi-annual	X	X	X	X							X	
299-W15-11	Semi-annual	X	X	X	X			X				X	

Table A3-2. Routine Sampling and Analysis Requirements for the 200-ZP-1 Operable Unit Groundwater Monitoring Well Network. (5 sheets)

Well Number	Sampling Frequency	Onsite			Offsite								
		Carbon Tetrachloride	Chloroform	TCE	Tc-99	Uranium	I-129	Tritium	Chromium (Total)	Arsenic	Cadmium	Nitrate	Other
299-W15-15	Annual	X	X								X	X	
299-W15-17	Semi-annual	X	X	X	X				X		X	X	
299-W15-30	Semi-annual	X	X	X	X				X		X	X	
299-W15-31A	Semi-annual	X	X	X	X							X	
299-W15-34	Annual	X	X	X	X							X	Methylene chloride
299-W15-35[7]	Annual	X	X	X	X				X			X	Methylene chloride
299-W15-36	Annual	X	X	X								X	Methylene chloride
299-W15-38	Annual	X	X	X					X			X	
299-W15-39	Semi-annual	X	X	X								X	
299-W15-40	Semi-annual	X	X	X	X			X	X		X	X	
299-W15-41	Semi-annual	X	X	X	X			X			X	X	
299-W15-42	Semi-annual	X	X	X	X				X		X	X	Iron, methylene chloride

Table A3-2. Routine Sampling and Analysis Requirements for the 200-ZP-1 Operable Unit Groundwater Monitoring Well Network. (5 sheets)

Well Number	Sampling Frequency	Onsite			Offsite								
		Carbon Tetrachloride	Chloroform	TCE	Tc-99	Uranium	I-129	Tritium	Chromium (Total)	Arsenic	Cadmium	Nitrate	Other
299-W15-43	Semi-annual	X	X	X	X			X				X	Manganese
299-W15-44	Semi-annual	X	X	X	X		X	X				X	Manganese
299-W15-45	Quarterly	X	X	X	X							X	
299-W15-47	Quarterly	X	X	X	X							X	
299-W18-1	Semi-annual	X	X	X							X	X	
299-W18-23	Annual	X	X		X	X						X	
299-W18-27	Annual	X	X	X		X						X	
699-43-89[5]	Biennial	X	X	X	X	X	X	X	X	X	X	X	Sr-90
699-44-64[5]	Biennial				X	X	X	X				X	
699-45-69A[5]	Biennial	X					X					X	
699-47-60[5]	Biennial	X	X	X	X	X	X	X	X			X	
699-48-71[5]	Biennial	X		X		X	X	X				X	
699-48-77A[5,7]	Biennial	X						X	X			X	Iron
699-55-60A[5]	Biennial	X	X	X	X	X	X	X	X			X	
New Well C[10] (299-W15-49)	Quarterly	X	X									X	
New Well D[10]	Quarterly	X	X	X								X	

Table A3-2. Routine Sampling and Analysis Requirements for the 200-ZP-1 Operable Unit Groundwater Monitoring Well Network. (5 sheets)

Well Number	Sampling Frequency	Onsite			Offsite								Other
		Carbon Tetrachloride	Chloroform	TCE	Tc-99	Uranium	I-129	Tritium	Chromium (Total)	Arsenic	Cadmium	Nitrate	
(299-W18-16)													
New Well E[10] (299-W15-50)	Quarterly	X	X	X					X			X	
New Well F[7,9]	Quarterly	X	X	X								X	
New Well G (299-W13[1])	Quarterly	X	X	X				X				X	
New Well H[9]	Quarterly	X				X							
New Well I (299-W17[1])	Quarterly	X	X	X	X		X	X	X			X	
New Well T[8]	Quarterly	X						X				X	

Quality Control Requirements: duplicates: 5%; equipment rinsate blanks: One per 10 well trips; field transfer blanks: One per day when VOAs are sampled.

[1] Semi-annual sampling will be conducted every other quarter, i.e. 1st and 3rd or 2nd and 4th quarters, FY 2005.
[2] Annual samples will be taken in either 3rd or 4th quarter, FY 2005.
[3] VOCs are 1, 2 dichloroethane, benezene, tetrachloroethene and methylene chloride.
[4] Biennial samples that ARE NOT scheduled for FY 2005.
[5] Biennial samples that ARE scheduled for FY 2005.
[6] Sampling frequency is consistent with that required by DOE/RL-2003-55, Rev. 0
[7] Does not include supplemental analyses to support RI/FS Process (See following tables starting on page 34)
[8] To be installed in FY 2006 or out years.
[9] To be installed in FY 2005.
[10] To be installed in early FY 2005.

A3.2.2 Routine Groundwater Monitoring Strategy

Table A3-2 presents the groundwater monitoring well network updated from a previous DQO summary report (FH 2003a). The selected frequency proposed for sampling the wells is dependent upon how many times a well has been sampled in the past. New wells are to be sampled quarterly the first year after installation, semi-annually the second year after installation, then annually from that point forward. Biennial sampling (i.e., every 2 years) is used for perimeter wells that have shown stable concentrations for several years. Conversely, if a well begins to show stable concentrations, the sampling frequency may decrease. If irregular or increasing trends appear, the sampling frequency may increase accordingly. Table A3-2 lists the existing and proposed wells in the 200-ZP-1 OU monitoring well network, presents the sample analyses for individual wells, and indicates the frequency at which samples will be collected.

With regard to the new groundwater monitoring wells proposed within the 200-ZP-1 OU, these wells will be installed in the out-years based on the priority given in Table A3-1 and budget availability.

A3.2.3 Monitoring for Additional Contaminants of Concern

During the preparation of the 200-ZP-1 DQO summary report (FH 2003b), a number of historical documents were researched for the purpose of identifying a comprehensive list of COPCs that should be taken into consideration when going through the CERCLA RI/FS process. A number of these COPCs were able to be eliminated after reviewing historical analytical data, radioactive half-life, soil adsorption, and toxicity. Those COPCs that were retained became the COCs that are undergoing evaluation in this work plan. Appendix D of the DQO summary report (FH 2003b) contains a list of all COPCs and the rationale for their inclusion or exclusion as COCs.

The implementation strategy to obtain information regarding these additional COCs is to sample specific wells in high concentration areas of the plumes and/or at wells immediately downgradient from selected waste sites. Two rounds of sampling are scheduled: the first in FY04 and the second in FY06. The results of the sampling and analysis will be evaluated and, if one or more of these additional COCs are detected, the supporting SAP will be updated to add these COCs to the routine sampling program. If the additional COCs are not detected, they will not be considered further in the RI/FS process. Table A3-3 presents the wells chosen for this additional sampling. These wells will be analyzed for all of the COCs listed in Table A1-2 and in accordance with the methods identified in Table A2-1.

A3.2.4 Modeling Input Parameters

The needed modeling input data (identified in Section A1.3.4 and Table A2-2) will be collected from the saturated zone of three selected wells (new wells "C," "H," and 299-W15-46) within the 200-ZP-1 OU or will be collected from these selected wells following well installation (e.g., well development and aquifer testing). These three wells were selected based on professional judgment to be representative of the 218-W-4B/218-W-2 Burial Grounds, T Plant, and Z Plant, respectively. The approximate locations for new wells "C" and "H" are shown on the plate map found in Appendix B. Well 299-W15-46 is currently being drilled on the south side of the Z-9 Crib. Table A1-6 identifies the modeling input parameter sampling and analysis requirements.

Table A3-3. 200-ZP-1 Operable Unit Groundwater Monitoring Network Wells Selected for Additional Contaminant of Concern Sampling and Analysis.[a]

Well Name[b]	Radiological COCs from Table A2-1	Nonradiological COCs from Table A2-1	Rationale for Selecting Well
299-W7-4	X	X	*Located near LLWMA 3; among several known plumes.*
299-W10-4	X	X	Well is located downgradient from plumes near T Plant.
299W11-14	X	X	Located inside of multiple plumes associated with T Plant.
299-W14-13	X	X	Located in the vicinity of non-tank farm cribs and TX-TY evaporator. This well contains some of the highest radionuclide concentrations in the 200 West Area.
New extraction well #4[c]	X	X	Located near the 216-Z-9 tile field; several plumes in the general area.
699-48-77A	X	X	Selected for its proximity to the SALDS; within the SALDS tritium plume.
New well F	X	X	Well is located between LLWMA 4 and the Z Plant complex. May provide insight regarding possible LLWMA 4 contributions to groundwater.

[a] The wells chosen for sampling are in areas of either known (or expected) high COC concentrations in groundwater. Generally, the wells are near sources that either have provided, or may have future potential to provide COCs to the groundwater. *Wells will be sampled in FY04 and FY06. Additional sampling in future years will be determined by* evaluation of results.
[b] These well are part of the current monitoring network (FH 2003) unless otherwise noted.
[c] Not part of the current monitoring network; new well to be installed in 2004.
COC = contaminant of concern
FY = fiscal year
LLWMA = Low-Level Waste Management Area
SALDS = State-Approved Land Disposal Site

Approximately five depth-discrete groundwater and soil samples shall be collected during the drilling of the three identified new wells. These samples shall be approximately evenly spaced between the top of the water table and the top of the Ringold Lower Mud Unit, or about 36.6 to 61.0 m (120 to 200 ft) below the top of the unconfined aquifer. Well 299-W15-46 will be drilled through the Ringold Lower Mud Unit to basalt, and an additional groundwater sample shall be collected from this interval. These samples shall be analyzed for the parameters identified in Table A2-2. These samples shall also be tested for the parameters identified in Table A2-1, as discussed in Section A1.3.3

These three new wells will be completed to screen the upper portion of the unconfined aquifer unless the highest concentration of contaminants is found at a deeper interval. In the latter case, RL and EPA will be consulted on the interval to be screened. The data obtained from these wells will allow more accurate modeling of plume movement and knowledge of the vertical distribution of the COCs.

A3.2.5 Three-Dimensional Distribution of Contaminants of Concern

To assist in defining the three-dimensional distribution of COCs within the unconfined aquifer, approximately five depth-discrete groundwater and soil samples collected from new wells "C," "H," and 299-W15-46 (described in Section A3.2.2) shall also be tested using the analytical methods described in Table A2-1.

In addition, wells "D," "E," "F," "G," "I," and "T" (shown in Appendix B) will be drilled 36.6 m (120 ft) below the water table and a series of depth-discrete groundwater samples will be collected beyond the samples indicated in Table A3-2. These depth-discrete samples will be collected at approximately 9.1-m (30-ft) intervals, for a total of four samples. These samples shall be analyzed for carbon tetrachloride, TCE, chloroform, and PCE. These four COCs have been selected as indicator COCs that will provide insight into the three-dimensional distribution of contaminants within the aquifer.

A3.2.6 Aquifer Testing

Detailed hydrologic testing will be conducted at approximately three well locations to provide required input characterization parameters for numerical groundwater models needed to evaluate fate and transport of contaminants. In general, from one to three hydrologic tests will be conducted at each of these well sites. Hydrologic tests that may be performed include the following: slug tests, slug interference tests, constant-rate discharge tests, and tracer tests (e.g., single- or dual-well tests).

Multiple depth intervals may be tested to provide an indication of the vertical distribution of hydraulic properties. For wells that are drilled to the Ringold Lower Mud Unit (Unit 9), as many as three depth intervals may be tested: one near the top of the aquifer, one near an intermediate zone, and one near the bottom of the unconfined aquifer. For wells that are already completed in the upper part of the aquifer, only the upper interval will be tested.

Hydrologic parameters of primary interest include the following: hydraulic conductivity, vertical anisotropy, longitudinal and transverse dispersivity, and effective porosity. Preference in the test characterization will focus on the use of test methods that provide larger-scale hydraulic property values, because this is consistent with the scale currently used by Hanford Site groundwater models. It is recognized that the disposal of purgewater (which may be generated using constant-rate discharge tests) may pose a problem at some well site locations. In these instances, the use of constant-rate discharge testing may be limited; however, a high priority will be given for testing the upper test interval in all wells (if possible) using this characterization method. Other hydrologic testing methods can be used for characterizing deeper test intervals within the aquifer.

Prior to developing a final detailed hydrologic test plan that identifies specific hydrologic test methods to be conducted, FH will discuss with PNNL the benefits of different test design options, well configurations, and well locations for performing characterization tests to maximize data quality. Data quality, however, may be constrained by existing test/site logistics (e.g., disposal of purgewater, presence or lack of monitoring wells, pump-and treat operational restrictions, etc.).

A3.2.7 Supplemental Data

The data resulting from implementation of this SAP may be supplemented by information derived from other groundwater investigations performed onsite. This supplemental information includes, but is not limited to, the following:

- Performing sampling and analysis activities required to monitor sites under RCRA
- Collecting water-level measurements
- Collecting pH, temperature, and conductivity readings
- Performing hydrologic testing and conducting DNAPL investigations
- Implementing quality assurance activities (e.g., Washington State Department of Health co-sampling)
- Possibly performing research activities.

The supplemental data may be used to help refine the conceptual site model and to provide information on contaminant movement through the vadose zone. Wells potentially providing supplemental information for the 200-ZP-1 network and the primary sampling purpose for each of these wells are presented in Appendix B of the RI/FS DQO summary report (FH 2003b).

A3.2.8 Dense Nonaqueous Phase Liquid Investigations

The presence or absence of DNAPLs in the 200-ZP-1 OU and its three-dimensional distribution within the OU is recognized as a data gap that needs to be filled to support the CERCLA RI/FS process. The DNAPL investigations in the vadose zone and groundwater in the vicinity of the 216-Z-9 Trench are currently being addressed by *Sampling and Analysis Plan for Investigation of Dense Nonaqueous Phase Liquid Carbon Tetrachloride at the 216-Z-9 Trench* (DOE-RL 2003). A separate SAP will be prepared to address the remainder of the DNAPL characterization strategy identified in Section 6.5 of *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units* (DOE-RL 2004). This DNAPL characterization data shall be available to support the CERCLA RI/FS project schedule identified in Figure 6-1 of the work plan.

A3.2.9 Sampling Design for Microscopic and Geochemical Analysis

A study of the geochemical process involved in the contaminant plume saturated zone requires as many as five, 2- to 5-kg (4.4- to 11.01-lb) aquifer sediment samples obtained from the near source, middle, and distal regions of the contaminated groundwater plume. These samples would be collected during drilling of proposed wells "C," "H," and 299-W15-46 (Table 5-2). The samples will be analyzed for the model input parameters described in Table A2-2. As described in Section 5.1.5 (main text of this work plan), these samples will also be tested using the analytical methods described in Table A2-1.

Using these samples, the following activities may also be performed to better characterize the behavior of transport mechanisms in the groundwater:

- Determination of retardation processes and sorbed/dissolved contaminant inventories in groundwater, and the kinetics of solid-liquid redistribution phenomena controlling migration and influencing potential remediation efficiency.
- A combination of microscopic contaminant characterization with advanced radiochemical, microscopic, and analytical techniques, and kinetic studies of desorption/dissolution rate will provide information necessary to assess the long-term behavior of contaminants in the vadose zone and contaminated groundwater at 200-ZP-1.

The experimental measurements will be interpreted with a suite of geochemical and mass transport models that are maintained and/or were developed by PNNL.

A3.3 WELL DRILLING PROCEDURES

Well drilling will be performed in accordance with CP-GPP-EE-02-14.0, "Drilling, Maintaining, Remediating, and Decommissioning Resource Protection Wells, Geoprobe, and Geotechnical Soil Borings," and WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells."

A3.4 SAMPLING PROCEDURES

The procedures to be implemented in the field should be in accordance with those outlined in DFSNW-SSPM-001 (or equivalent), including the following:

- Procedure 1-1, "Chain of Custody/Sample Analysis Request"
- Procedure 1-2, "Project and Sample Identification for Sampling Services"
- Procedure 1-5, "Field Logbooks"
- Procedure 2-5, "Laboratory Cleaning of Sampling Equipment"
- Procedure 2-6, "Sample Packaging and Shipping"
- Procedure 3-1, "Groundwater Sampling"
- Procedure 6-1, "Control of Monitoring Instruments"
- Procedure 6-2, "Turbidity Measurements"
- Procedure 6-3, "pH Measurements"
- Procedure 6-5, "Field Analysis of Conductivity using the YSI Model 30 Conductivity/ Salinity and Temperature Meter"
- Procedure 6-7, "Temperature."

Purgewater management shall be implemented in accordance with FH procedure CP-GPP-EE-01-1.11, "Purgewater Management."

A3.5 SAMPLE MANAGEMENT

Sample and data management activities will be performed in accordance with FH's *Project Hanford Quality Assurance Program Description* (HNF-MP-599) and bluesheeted BHI-QA-03, *Quality Assurance Program Plans*, Plan No. 5.1, "Field Sampling Quality Assurance Program Plan," or subsequent and equivalent FH quality assurance program plans.

Sample preservation, container, and holding-time requirements will be specified on sampling authorization forms and chain-of-custody forms in accordance with the requirements specified in RFS (1999) (or equivalent) and the specific analytical method prepared for specific sample events.

A3.5.1 Sample Custody

All samples obtained during the project will be controlled from the point of origin to the analytical laboratory, as required by HASQARD, Vol. 2, "Sampling Technical Requirements" (DOE-RL 1998), and DFSNW-SSPM-001, Procedure 1-1, "Chain of Custody/Sample Analysis Request" (or equivalent).

A3.5.2 Sample Packaging and Shipping

Sample custody during laboratory analysis will be addressed in the applicable laboratory's standard operating procedures.

A3.5.3 Field Documentation

Sample preservation and container details will be addressed on the sampling authorization form and chain-of-custody form in accordance with the requirements specified in HASQARD, Vol. 4, "Laboratory Technical Requirements" (DOE-RL 1998); RFS (1999) (or equivalent); and analytical method requirements.

A3.6 MANAGEMENT OF WASTE

The FH waste management procedures HNF-PRO-455, *Solid Waste Management*, and HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria* (FH 2003c) (as required), address the management of waste.

Waste generated by sampling activities will be managed in accordance with an established waste management plan and the requirements of DFSNW-SSPM-001 (or equivalent). Investigation-derived wasted from these sampling activities will be handled as CERCLA waste. Unused samples and associated laboratory waste for the analysis will be dispositioned in accordance with the laboratory contract and agreements for return to the Hanford Site. In accordance with DFSNW-SSPM-001 and 40 *Code of Federal Regulations* (CFR) 300.440, Remedial Project Manager approval is required before returning unused samples or waste from offsite laboratories.

A waste management plan (DOE-RL 2000) has been prepared for the 200-ZP-1 OU. The waste management plan establishes the requirements for management and disposal of waste generated from groundwater wells that are used to monitor the 200-ZP-1 OU, as required by the *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit* (EPA et. al. 1995).

The waste management plan (DOE-RL 2000) will be updated following the approval of this SAP. The update to the waste management plan will occur prior to implementation of this SAP to support FY03 groundwater well monitoring network sampling.

A3.7 WELL DECOMMISSIONING

Wells requiring decommissioning will be identified and prioritized on an annual basis. These wells will be decommissioned in accordance with WAC 173-160.

A4.0 HEALTH AND SAFETY

All field operations will be performed in accordance with FH, or its approved subcontractor's, health and safety plan (or equivalent), and the requirements of the most recent Waste Management Project radiological control procedures (or equivalent). Where necessary, a work planning package will include a job hazard analysis and/or site-specific health and safety plan, and applicable radiological work permits, as appropriate. The job hazard analysis has been and may continue to be used for ongoing sampling activities that are already underway. However, with more extensive work performed (e.g., drilling), a site-specific plan is currently being written.

A5.0 REFERENCES

40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," *Code of Federal Regulations*, as amended.

Atomic Energy Act of 1954, 42 U.S.C. 2011, et seq.

BHI, 2000a, *Data Validation Procedure for Chemical Analysis*, BHI-01435, Rev. 0, Bechtel Hanford, Inc. Richland, Washington.

BHI, 2000b, *Data Validation Procedure for Radiochemical Analysis*, BHI-01433, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 2001, *Remedial Investigation Data Quality Objectives Summary Report for the 200-PW-1 Operable Unit Phase I Representative Waste Sites*, BHI-01477, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI-QA-03, *Quality Assurance Program Plans*, Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

CP-GPP-EE-01-1.11, "Purgewater Management," Fluor Hanford, Inc., Richland, Washington.

CP-GPP-EE-02-14.0, "Drilling, Maintaining, Remediating, and Decommissioning Resource Protection Wells, Geoprobe, and Geotechnical Soil Borings," Fluor Hanford, Inc., Richland, Washington.

DFSNW-SSPM-001, *Sampling Service Procedure Manual*, Duratek Federal Services, Northwest Operations, Richland, Washington.

DOE-RL, 1992a, *Hanford Site Groundwater Background*, DOE/RL-92-93, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1992b, *T Plant Source Aggregate Area Management Study Report*, DOE/RL-91-61, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1993, *200 West Groundwater Aggregate Area Management Study Report*, DOE/RL-92-16, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1998, *Hanford Analytical Services Quality Assurance Requirements Document*, DOE/RL-96-68, Rev. 2, Vols. 1, 2, and 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1999, *200 Areas Remedial Investigation/Feasibility Study Implementation Plan – Environmental Restoration Program*, DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2000, *Waste Management Plan for the Expedited Response Action for 200 West Area Carbon Tetrachloride Plume and the 200-ZP-1 and 200-PW-1 Operable Units*, DOE/RL-2000-40, Rev.-4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2001, *Drilling, Sampling, and Analysis Plan for Installation of a Well Within the Vicinity of the Plutonium Finishing Plant*, DOE/RL-2001-37, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2003, *Sampling and Analysis Plan for the Investigation of Dense Nonaqueous Phase Liquid Carbon Tetrachloride at the 216-Z-9 Trench*, DOE/RL-2003-41, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2004, *Plutonium/Organic-Rich Process Condensate/Process Waste Group Operable Unit RI/FS Work Plan: Includes the 200-PW-1, 200-PW-3, and 200-PW-6 Operable Units*, DOE/RL-2001-01, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Eaton, A. D., L. S. Clesceri, A. E. Greenberg, 1995, *Standard Methods for Examination of Water and Wastewater*, 19th edition, American Public Health Association, Washington, D.C.

Ecology, 2001, *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation (CLARC), Version 3.1*, Publication No. 94-145, Washington State Department of Ecology, Toxics Cleanup Program, Olympia, Washington.

Ecology, EPA, and DOE, 2003, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), 2 vols., as amended, 89-10, Rev. 6, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

EPA, 1997, *Test Methods for Evaluation Solid Waste, Physical/Chemical Methods*, SW-846, 3rd edition (as amended by Update I [July 1992], Update IIA [August, 1993], Update IIB [January 1995], and Update III), U.S. Environmental Protection Agency, Washington, D.C.

EPA, 2000, *Guidance for the Data Quality Objectives Process*, EPA QA/G-4, EPA/600/R-96/055, U.S. Environmental Protection Agency, Environmental Protection Office of Environmental Information, Washington, D.C.

EPA, Ecology, and DOE, 1995, *Declaration of the Interim Record of Decision for the 200-ZP-1 Operable Unit*, Document #016085, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

EPA, Ecology, and DOE, 1997, *Record of Decision for the 200-UP-1 Interim Remedial Measure*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

FH, 2003a, *Data Quality Objective Summary Report for Establishing a RCRA/CERCLA/AEA Integrated 200 West and 200 East Groundwater Monitoring Network*, CP-15329, Rev. 0, Fluor Hanford, Richland, Washington.

FH, 2003b, *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process*, CP-16151, Rev. 0, Fluor Hanford, Richland, Washington.

FH, 2003c, *Hanford Site Solid Waste Acceptance Criteria*, HNF-EP-0063, Rev. 8, Fluor Hanford, Inc., Richland, Washington.

HNF-MP-599, *Project Hanford Quality Assurance Program Description*, Fluor Hanford, Inc., Richland, Washington.

HNF-PRO-455, *Solid Waste Management*, Fluor Hanford, Inc., Richland, Washington.

Kincaid, C. T., M. P. Bergeron, C. R. Cole, M. D. Freshley, N. L. Hassig, V. G. Johnson, D. I. Kaplan, R. J. Serne, G. P. Streile, D. L. Strenge, P. D. Thorne, L. W. Vail, G. A. Whyatt, and S. K. Wurstner, 1998, *Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site*, PNNL-11800, Pacific Northwest National Laboratory, Richland, Washington.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

RFS, 1999, *Statement of Work for Environmental and Waste Characterization Analytical Services*, RFSH-SOW-0003, Rev. 6, Rust Federal Services, Richland, Washington.

Routson, R. C., R. E. Wildung, and R. J. Serne, 1973, "A Column Cation-Exchange-Capacity Procedure for Low-Exchange Capacity Sands," *Soil Science*, Vol. 115, p. 107.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, as amended.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, as amended.

APPENDIX B

PLATE MAP

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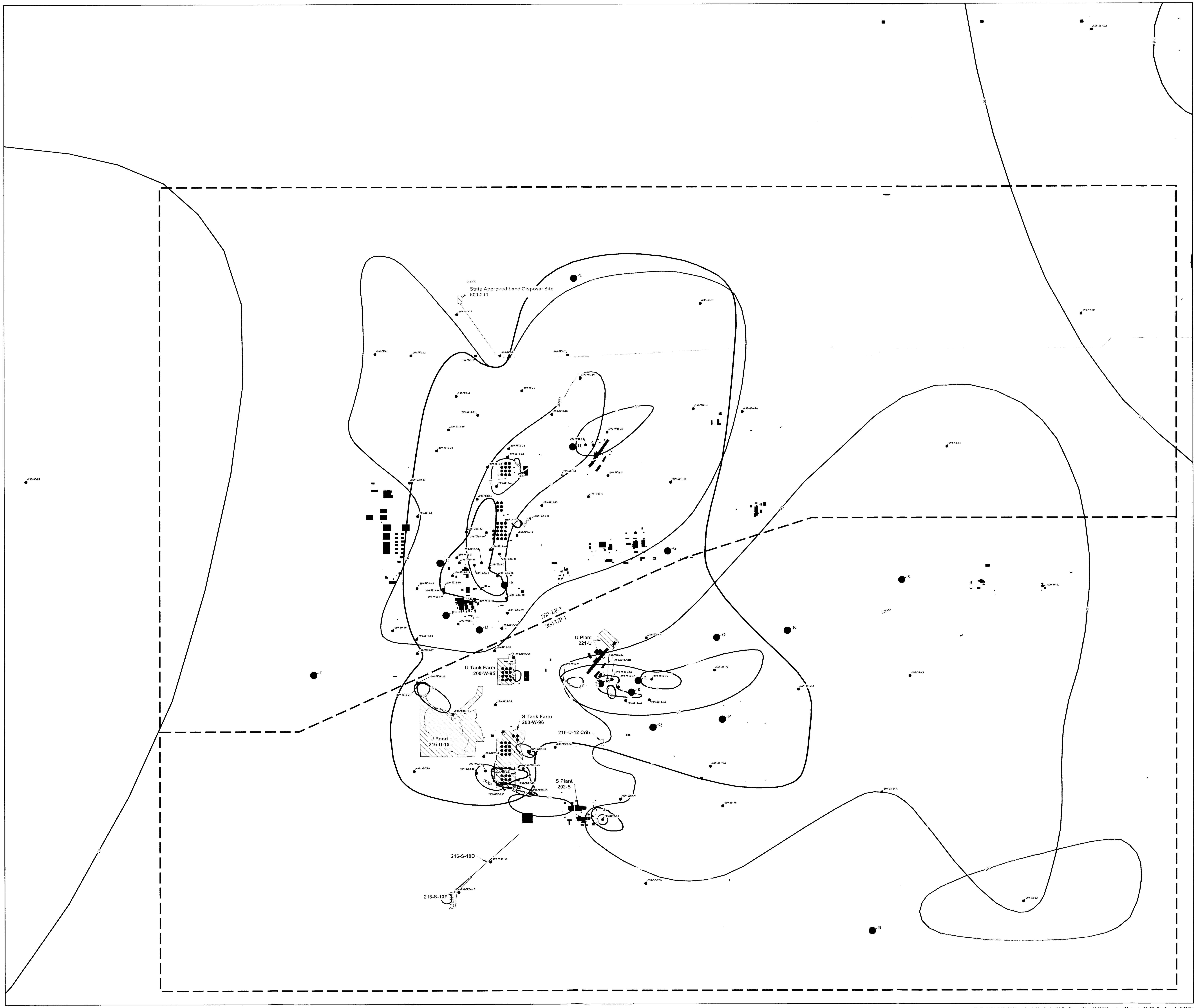
Proposed 200-UP-1 and 200-ZP-1 Monitoring Network

● Proposed Monitoring Well
— — Operable Unit Boundary
Associated Waste Sites

2003 Sample Data

- Chromium Concentrations 100 ug/L
- Carbon Tetrachloride Concentrations 5 and 2000 ug/L
- Iodine-129 Concentrations 1 pCi/L
- Nitrate Concentrations 20 mg/L
- Strontium 90 Concentrations 8 pCi/L
- Technetium-99 Concentrations 900 pCi/L
- Trichloroethylene Concentrations 5 ug/L
- Tritium Concentrations 20,000 pCi/L
- Uranium Concentrations 30 pCi/L



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0 1,000 2,000 4,000 Feet

CMS

Prepared for:
US DEPARTMENT OF ENERGY
RICHLAND OPERATIONS OFFICE

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APPENDIX C

SELECTION LOGIC FOR ADDITIONAL CONTAMINANTS OF CONCERN

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TERMS

AEA	*Atomic Energy Act of 1954*
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CLARC	*Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation*
COC	contaminant of concern
CRDL	contract-required detection limit
DCG	derived concentration guideline
DOE	U.S. Department of Energy
DP	data point
DQO	data quality objectives
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FH	Fluor Hanford, Inc.
FY	fiscal year
HEIS	Hanford Environmental Information System
MCL	maximum contaminant level
MPC	maximum permissible concentration
N/A	not applicable
NBS	National Bureau of Standards
OU	operable unit
PCB	polychlorinated biphenyl
RCRA	*Resource Conservation and Recovery Act of 1976*
RI/FS	remedial investigation/feasibility study
SQL	structured query language
TCE	trichloroethylene
WAC	*Washington Administrative Code*

C1.0 SELECTION LOGIC FOR ADDITIONAL CONTAMINANTS OF CONCERN

C1.1 CONTAMINANTS OF CONCERN

Historical information regarding contaminants of concern (COCs) at the 200-ZP-1 Groundwater Operable Unit (OU) was obtained primarily from six documents. A list of all of the COCs from these reference documents was prepared and evaluated to determine if any of the constituents could be eliminated because of short half-lives, low potential dose/risk rates, high soil retardation, or other factors (FH 2003b). Appendix D of the remedial investigation/feasibility study (RI/FS) data quality objectives (DQO) summary report (FH 2003b) provides the list of all radiological (Table D-1) and nonradiological COCs (Table D-2) that were identified, as well as the general logic for including or excluding a particular COC.

Fluor Hanford, Inc. (FH) performed an additional evaluation of constituents after the initial removal of COCs was performed. This additional screening included the following:

- Evaluation of the data in the Hanford Environmental Information System (HEIS) database by constituent and well
- Evaluation of detects versus nondetects over time
- Evaluation of detects versus regulatory limits
- Comparison of the minimum, maximum, and standard deviations by well and COC.

This appendix documents the results of these additional evaluations.

C1.2 ROUTINELY MONITORED CONTAMINANTS OF CONCERN

The middle column of Table C1-1 presents a list of groundwater COCs generated for the 200-ZP-1 OU to fulfill the currently defined routine monitoring requirements for the combined *Resource Conservation and Recovery Act of 1976* (RCRA)/*Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA)/*Atomic Energy Act of 1954* (AEA) groundwater monitoring network (FH 2003a). This initial list of COCs also provided the currently defined baseline monitoring list for the RI/FS DQO summary report (FH 2003b). As a result of the evaluation of monitoring results from individual wells discussed in this appendix, several additional COCs were added to the analyses of the monitoring well network for specific wells. These COCs are listed in the right column of Table C1-1.

C1.3 ADDITIONAL CONTAMINANT OF CONCERN EVALUATION

FH evaluated the need for additional data to determine the nature and extent of contamination in the groundwater, perform a risk assessment, and evaluate remedial action alternatives in support of the RI/FS process (FH 2003b). As a result, some COCs beyond those routinely analyzed in the current well monitoring network were identified to support the eventual RI/FS activities associated with closing the site under CERCLA.

Table C1-1. Routinely Monitored Contaminants of Concern.

Media	Initial Routine Monitoring COCs (FH 2003a)	Additional Monitoring COCs (FH 2003b)
Radiological		
Groundwater	I-129, Tc-99, uranium, H-3, Sr-90	None
Nonradiological		
Groundwater	Carbon tetrachloride, chloroform, trichloroethylene (TCE), chromium (total), arsenic, cadmium, nitrate	Antimony, iron, methylene chloride, manganese, benzene, 1,2-dichloroethane, tetrachloroethylene, fluoride

COC = contaminant of concern

In addition to the routine monitoring COCs discussed in Section C1.2, a number of COCs were potential contributors to groundwater contamination but either have no data to determine their presence or may reach the groundwater in the future. The implementation strategy to obtain information regarding these additional COCs is to sample specific wells in high-concentration areas of the plumes and/or at wells immediately downgradient from selected waste sites. Two rounds of sampling are scheduled: the first in fiscal year 2004 (FY04), and the second in FY06. The results of the sampling and analysis will be evaluated and, if one or more of these additional COCs are detected above the preliminary target action levels as indicated in Table A1-7 of Appendix A, the supporting sampling and analysis plan will be updated to add these COCs to the routine sampling program. Table A3-3 in Appendix A identifies the wells that have been selected for additional sampling. The wells will be analyzed for the COCs and analytical methods identified in Table A2-1 (Appendix A).

C1.3.1 Evaluation of Contaminants of Concern

To examine the levels of current groundwater contamination and to evaluate the concentration of COCs as a function of time and location, the HEIS database was queried. The Virtual Library allows rapid queries of the HEIS database for groundwater data. The Virtual Library was used to query historical data (January 1992 through August 2003) for all of the wells chosen to be in the routine monitoring network for the 200-ZP-1 OU. The resulting data included information for the following types of constituents: metals, non-metals, polychlorinated biphenyls and pesticides, radiological constituents, semi-volatile organic compounds, and volatile organic compounds. The HEIS database queries were not limited to the COCs already identified during literature searches (Table C1-1), but were for all constituents associated with 200-ZP-1 OU wells in HEIS, as noted in Table C1-2.

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
Metals				
Antimony	N/A	10	µg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details.
Arsenic	10[b,l]	10	µg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details.
Cadmium	<10[e,l]	5	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Chromium	<30[e,l]	100	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Hexavalent chromium	N/A	48	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Iron	86[b,l]	300	µg/L	2°MCL[g] (http://www.epa.gov/safewater/mcl.html).
Lead	<5[e,l]	15	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html); MCL from treatment technique action level.
Lithium	N/A	N/A	µg/L	No regulatory limits available; results ranged from 0 to 6.3 µg/L.
Magnesium	16,480[a,l]	N/A	µg/L	No regulatory limits available; results ranged from 4,490 to 79,000 µg/L.
Manganese	24.5[b,l]	50	µg/L	2° MCL[g] (http://www.epa.gov/safewater/mcl.html).
Mercury	<0.1[e,l]	2	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Nickel	<30[e,l]	320	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Selenium	<5[e,l]	50	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Silver	<10[c,e,l]	80	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Uranium	3.43[b,l]	30	µg/L	1°MCL[f] (40 CFR 141.66).
Vanadium	15[b,l]	112	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Zinc	<50[e,l]	4,800	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
Non-Metals				
Ammonium ion	120[h,l]	N/A	µg/L	No regulatory limits available; results range from 0 to 200 µg/L.
Chloride	8,690[h,l]	250,000	µg/L	2°MCL[g] (http://www.epa.gov/safewater/mcl.html).
Cyanide	N/A	200	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Fluoride	775[b,k,l]	4,000	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Nitrate as N	2,800[h,l]	2,800	µg/L	Background level used as regulatory limit. See Table A1-7 (Appendix A) for details.
Nitrite as N	N/A	1,000	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Phosphate	<1,000[d,e,l]	N/A	µg/L	No regulatory limits available; results range from 0 to 1,000 µg/L.
Sulfate	90,500[h,l]	250,000	µg/L	2°MCL[g] (http://www.epa.gov/safewater/mcl.html).
PCBs/Pesticides				
Aldrin	N/A	5.15E-03	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Aroclor-1016	N/A	0.5	µg/L	1°MCL[f]; limit is for all aroclors, combined (http://www.epa.gov/safewater/ mcl.html).
Aroclor-1221	N/A	0.5	µg/L	1°MCL[f]; limit is for all aroclors, combined (http://www.epa.gov/safewater/ mcl.html).
Aroclor-1232	N/A	0.5	µg/L	1°MCL[f]; limit is for all aroclors, combined (http://www.epa.gov/safewater/ mcl.html).
Aroclor-1242	N/A	0.5	µg/L	1°MCL[f]; limit is for all aroclors, combined (http://www.epa.gov/safewater/ mcl.html).
Aroclor-1248	N/A	0.5	µg/L	1°MCL[f]; limit is for all aroclors, combined (http://www.epa.gov/safewater/ mcl.html).

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
Aroclor-1254	N/A	0.160	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Aroclor-1260	N/A	0.5	µg/L	1°MCL[f]; limit is for all aroclors, combined (http://www.epa.gov/safewater/mcl.html).
Dieldrin	N/A	5.47E-03	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Endrin aldehyde	N/A	N/A	µg/L	No regulatory limits available; all results have "U" qualifiers.
Endrin	N/A	2	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Gamma-BHC (Lindane)	N/A	0.0673	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Heptachlor	N/A	0.0194	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Radiological				
Americium-241	N/A	1.2	pCi/L	1/25th of the DCG[j] (DOE-RL 2002).
Carbon-14	N/A	2,000	pCi/L	MCL calculated from the NBS MPC (DOE-RL 2002).
Cesium-137	N/A	60	pCi/L	MCL calculated from the NBS MPC (DOE-RL 2002).
Europium-152	N/A	200	pCi/L	MCL calculated from the NBS MPC (DOE-RL 2002).
Europium-154	N/A	60	pCi/L	MCL calculated from the NBS MPC (DOE-RL 2002).
Europium-155	N/A	600	pCi/L	MCL calculated from the NBS MPC (DOE-RL 2002).
Gross alpha	5.79[l]	15	pCi/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Gross beta	12.62[l]	4	mrem/yr	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
Iodine-129	3.12E-05[m]	1	pCi/L	Regulatory limit calculated from the NBS MPC (DOE-RL 2002). Concentration that will result in 4 mrem/yr or less to the whole body or an organ.
Neptunium-237	N/A	15	pCi/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Plutonium-238	6.43E-05[m]	1.6	pCi/L	1/25th of the DCG[j] (DOE-RL 2002).
Plutonium-239/240	N/A	1.2	pCi/L	1/25th of the DCG[j] (DOE-RL 2002).
Potassium-40	2.47[m]	N/A	pCi/L	No regulatory limits available; results range from −121 to 391 µCi/L.
Strontium-90	3.77E-03[m]	8	pCi/L	Calculation from the EPA drinking water regulatory requirements that will result in 4 mrem/yr or less to the whole body or an organ (40 CFR 141.66).
Technetium-99	N/A	900	pCi/L	MCL calculated from the NBS MPC (DOE-RL 2002).
Tritium	N/A	20,000	pCi/L	1°MCL[f] (40 CFR 141.66).
Uranium-233/234	N/A	20[h]	pCi/L	Calculation from the EPA drinking water MCL of 30 µg/L (BHI 2001). Limit is for all uranium isotopes combined.
Uranium-234	N/A			
Uranium-235	N/A			
Uranium-238	N/A			

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
Semi-Volatile Organic Compounds				
2,4,6-trichlorophenol	N/A	7.95	μg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
2,6-dichlorophenol	N/A	N/A	μg/L	No regulatory limits available; all results have "U" qualifiers.
Bis(2-ethylhexyl) phthalate	N/A	6	μg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
N-nitrosodimethylamine	N/A	1.72E-03	μg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Pentachlorophenol	N/A	1	μg/L	CRDL is used in lieu of regulatory limit. WAC 173-340-720(4) Method B limit is 0.729 μg/L, MCL is 1 μg/L.
Phenol	N/A	9,600	μg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Total cresols	N/A	80	μg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001); m-, o- and p- isomers have different limits; value chosen is lowest limit (of p- isomer).
Total petroleum hydrocarbons = kerosene range	N/A	N/A	μg/L	No regulatory limits available; all results have "U" qualifiers.
Tributyl phosphate	N/A	N/A	μg/L	No regulatory limits available; all results have "U" qualifiers.
Volatile Organic Compounds				
1,1,1-trichloroethane	N/A	200	μg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
1,1-dichloroethylene	N/A	7	μg/L	CRDL is used in lieu of regulatory limit. WAC 173-340-720(4) Method B limit is 0.0729 μg/L, MCL is 7 μg/L.
1,2-dichloroethane	N/A	5	μg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details.
1,2-dichloroethylene (total)	N/A	70	μg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html); cis- and trans- isomers have different limits; value chosen is lowest limit (of trans- isomer).
1-butanol	N/A	1,600	μg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
2-butanone (methyl ethyl ketone)	N/A	4,800	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
4-methyl-2-pentanone	N/A	640	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Acetone	N/A	800	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Benzene	N/A	5	µg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details..
Carbon disulfide	N/A	800	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Carbon tetrachloride	N/A	3	µg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details..
Chlorobenzene	N/A	100	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Chloroform	N/A	7.17	µg/L	WAC 173-340-720(4) Method B[i] (Ecology 2001).
Methylene chloride	N/A	5	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Tetrachloroethylene	N/A	5	µg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details.
Toluene	N/A	1,000	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Trichloroethylene	N/A	5	µg/L	CRDL is used in lieu of regulatory limit. See Table A1-7 (Appendix A) for details.
Xylenes (total)	N/A	10,000	µg/L	1°MCL[f] (http://www.epa.gov/safewater/mcl.html).
Water				
Alkalinity	210,000 to 215,000[h,l]	N/A	µg/L	No regulatory limits available; results range from 45,700 to 980,000 µg/L.
pH measurement	6.90 to 8.25[a,l]	6.5 to 8.5	pH units	2°MCL[g] (http://www.epa.gov/safewater/mcl.html); pH ranges from 5.95 to 11.39.

Table C1-2. Contaminants and Preliminary Target Action Limits. (7 sheets)

Constituent	Background	Preliminary Target Action Limit	Units	Comment
Specific conductance	N/A	N/A		No regulatory limits available; results range from 127 to 3,427 µS/cm.
Total organic carbon	1,610[k,l]	N/A	µg/L	No regulatory limits available' some results above background; results range from 110 to 3,200 µg/L.
Total organic halides	N/A	N/A		No regulatory limits available; results range from 2.38 to 7,300 µg/L.

a Based on normal distribution (DOE-RL 1992).
b Based on non-parametric tolerance interval, maximum value reported (DOE-RL 1992).
c From *Hanford Site Groundwater Background* (DOE-RL 1992); based on inductively coupled plasma/mass spectroscopy data.
d From springs data (DOE-RL 1992).
e "<" indicates that the compound was analyzed for but not detected. Reported value after the "<" sign is the detection limit (DOE-RL 1992).
f MCLs are the highest level of a contaminant that is allowed in drinking water. The MCLs are set as close to MCL goal as feasible using the best available treatment technology and taking cost into consideration. The MCLs are enforceable standards; the MCL data in this table are from EPA's groundwater/drinking water web site (http://www.epa.gov/safewater/mcl.html), except as noted.
g National secondary drinking water regulations (or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (e.g., skin or tooth discoloration) or aesthetic effects (e.g., taste, odor, or color) in drinking water.
h The EPA has promulgated a drinking water MCL of 30 µg/L for total uranium (40 CFR 141.66). Based on the isotopic distribution of uranium on the Hanford Site, the 30 µg/L MCL corresponds to 21.2 pCi/L. Value rounded down for table. Mass concentration to activity calculation are documented in *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Uranium of 30 Micrograms per Liter in Groundwater* (BHI 2001).
i WAC 173-340-720(4) Method B refers to the *Model Toxics Control Act* (WAC 173-340). WAC 173-340-720(4) Method B data in this table are from Ecology (2001).
j DCGs are from DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*
k Potential outlier observations were removed (DOE-RL 1992).
l Background obtained from *Hanford Site Groundwater Background* (DOE-RL 1992).
m Background concentrations are arithmetic means calculated from samples collected from four monitoring wells upgradient of the 200-UP-1 Operable Unit (wells 699-19-98, 699-43-88, 699-55-76, and 699-55-89) (DOE-RL 1996).

CFR = *Code of Federal Regulations*
CRDL = contract required detection limit
DCG = derived concentration guideline
DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
HEIS = Hanford Environmental Information System
MCL = maximum contaminant level
MPC = maximum permissible concentration
N/A = not applicable
NBS = National Bureau of Standards
PCB = polychlorinated biphenyl
WAC = *Washington Administrative Code*

The results for each constituent were evaluated by comparing individual contaminant results (from actual data for existing wells) to a selected regulatory limit. The logic for deriving these limits is explained in the next paragraph. In addition, applicable Hanford Site groundwater background concentrations were listed from two available documents (DOE-RL 1992, 1996). The background values in the report for metals, non-metals, and total alpha/beta were compiled from the evaluation of data and information pertaining to the natural composition of groundwater in the unconfined aquifer system beneath the Hanford Site (DOE-RL 1992). Provisional background threshold levels were estimated from the data presented in the report. Background concentrations were available for many of the inorganic and radionuclide constituents but not for organic constituents. If a background concentration for any COC was not available, the background was assumed to be zero. Background concentrations for several of the radiological COCs (i.e., iodine-129, plutonium-238, potassium-40, and strontium-90) are arithmetic means calculated from samples collected from four monitoring wells located upgradient of the 200-UP-1 OU. These wells (699-19-98, 699-43-88, 699-55-76, and 699-55-89) were reported in the *Limited Field Investigation for the 200-UP-1 Operable Unit* (DOE-RL 1996) but were considered applicable to the 200-ZP-1 OU.

Table C1-2 lists the COCs found in the HEIS database, as well as the lowest regulatory limit, selected between the U.S. Environmental Protection Agency's (EPA's) primary maximum contaminant level (MCL) (40 *Code of Federal Regulations* [CFR] 141) and the *Model Toxics Control Act* (*Washington Administrative Code* [WAC] 173-340-740[4]) Method B limit. If neither a primary MCL nor WAC 173-340-740(4) limit were available for a particular analyte, a secondary MCL, if available, was used as the limit. The MCL levels were obtained from EPA's drinking waters standards, as published in April 2004 on EPA's web site (http://www.epa.gov/safewater/mcl.html). The WAC 173-340-740(4) Method B carcinogen formula values (preferred) or noncarcinogenic formula values were selected from data published in *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation (CLARC), Version 3.1* (Ecology 2001). In cases where no regulatory limits exist for a particular COC, a value of "N/A" was placed in the table. Applicable background information is also included in Table C1-2.

Current MCLs for radionuclides are set at 4 mrem/yr for the sum of the doses from beta particles and photon emitters, and 15 pCi/L for total alpha particle activity (including radium–226, but excluding uranium and radon). The MCL for total uranium is 30 µg/L (40 CFR 141.66). The current MCLs for beta emitters specify that the MCLs are to be calculated based on an annual dose equivalent of 4 mrem to the total body or any internal organ. It is further specified (40 CFR 141.66) that the calculation is to be performed on the basis of a 2-L/day drinking water intake using the 168-hour data listed in *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure* (Handbook 69) (NBS 1963). The values used for beta and gamma emitters in Table C1-2 were obtained from previous calculations of the estimated drinking water concentration that would result 4 mrem/yr (MCL) to the whole body or an organ if the groundwater water were used as drinking water (DOE-RL 2002).

C1.3.2 Evaluation Criteria

The evaluation was conducted in two phases. Phase I looked at the COCs identified in the groundwater monitoring network DQO (FH 2003a), which are listed in the left most column of

Table C1-1. Phase II looked at the remainder of the analytes that have been reported for these same wells over the last 10 years.

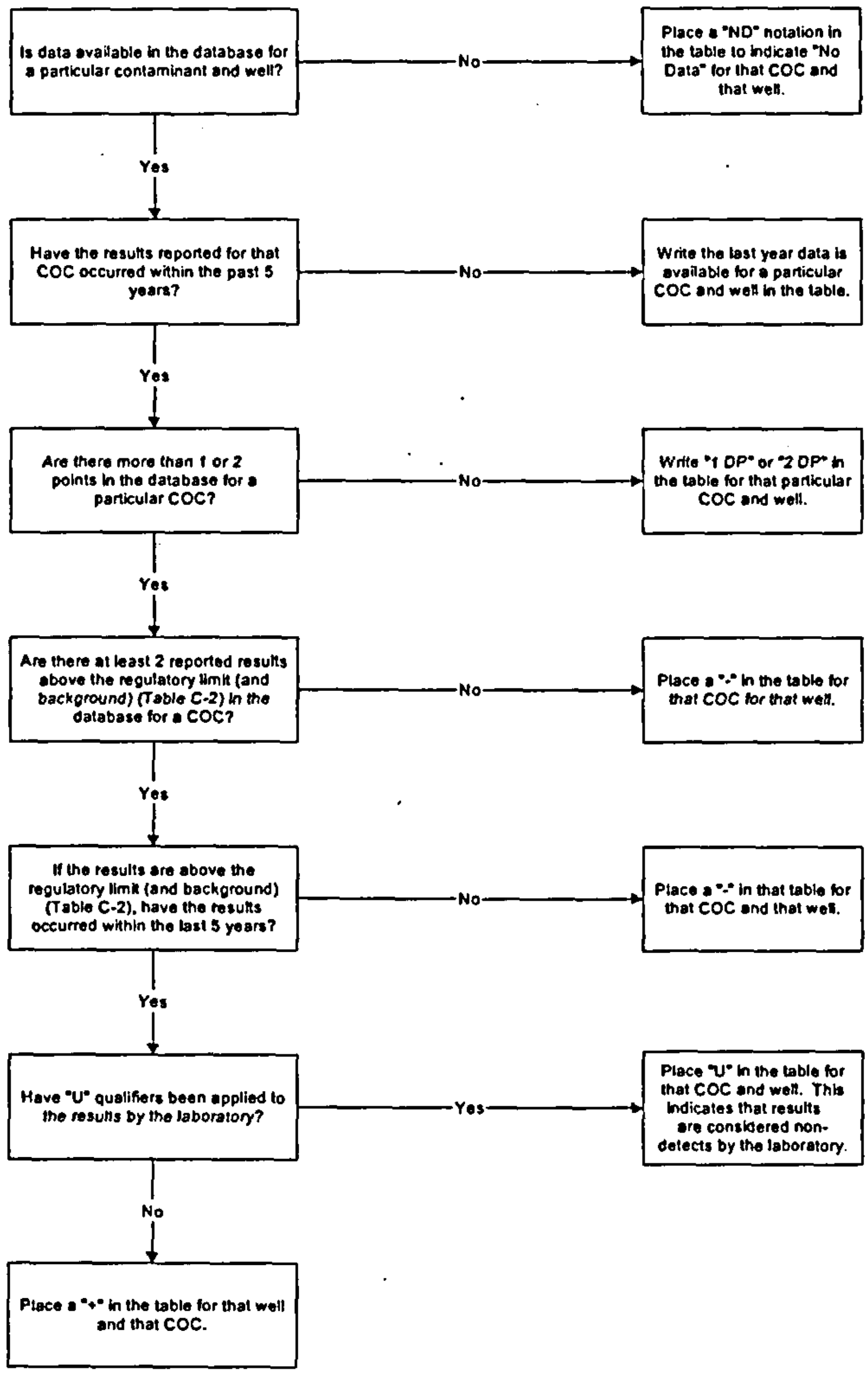
For each constituent in Table C1-2, all results for the 200-ZP-1 OU wells were queried for the last 10 years (January 1992 through August 2003). The data were compared to an action limit through a process that is described in more detail in subsequent sections. The action limit was the lowest of the regulatory limits that were available and achievable, taking into consideration the detection limit of the analysis and background levels. In Phase I, the analytical constituents and wells listed in Table A3-2 of Appendix A were evaluated against the information in the database. Tables A3-2 of Appendix A indicates, by contaminant and well, those constituents currently sampled/analyzed, and at what frequency. An "X" in Table A3-2 indicates that a COC has been requested for a given well in the groundwater monitoring network (FH 2003a).

For each contaminant, the background levels (if available) were compared against the regulatory limit. The background values were lower than the regulatory limit for all constituents except nitrate. The lowest regulatory limit for nitrate (as nitrogen) (Ecology2001) is 1,600 µg/L, with a background of 2,800 µg/L. Therefore, the background level of 2,800 µg/L was used to evaluate nitrate in the database. It should also be noted that some background numbers reported in *Hanford Site Groundwater Background* (DOE-RL 1992) are actually detection limits. For those background values reported as "<," a specific amount indicates that a compound was analyzed for but was not detected above the detection limit. These values were not used for background comparison purposes.

In some cases, regulatory limits were lower than achievable detection limits. In these cases, the constituent was evaluated against its contract-required detection limit (CRDL), as indicated in Table C1-2. Using the appropriate action limit (i.e., regulatory limit, CRDL or background level), the reported results for each contaminant were evaluated, as shown in Figure C1-1. The list below provides details of the logic.

- "X" in the table indicates that a contaminant had been selected for routine analysis in a particular well through previous documents and evaluations.
- "ND" in the table indicates that no data were found in the database for a particular contaminant and well.
- For some of the wells, the available data were generated more than 5 years ago. This is noted by writing the last year that the data were available for a particular contaminant in the table. For example, if the last year that data were available for a particular well and contaminant is 1998, then "'98" is used in the table. A flow diagram shows the logic of the criteria in Figure C1-1.
- If only one or two data points were found in the database for a particular contaminant, "1 DP" or "2 DP" is used to indicate this in the table.
- If none of the database results, or if only one data point was ≥ the MCL or WAC 173-340-720(4) Method B limit within the past 5 years, then a "-" was placed in the box for that well and contaminant.

Figure C1-1. Flow Diagram.



- If the database results for any contaminant were ≥, the MCL or WAC 173-340-720(4) Method B limit (and background), but the laboratory put a "U" qualifier next to those results, the "U" qualifier indicates that the result was considered a nondetect by the laboratory. The "U" was placed in the box for that well and contaminant and may indicate the need for a lower detection limit to adequately monitor a specific COC.
- If two or more reported results for an individual contaminant were ≥ the MCL or WAC 173-340-720(4) Method B limit, and those results occurred within the last 5 years, then a "+" was placed in the box for that well. If there was not already an "X" in the box, this indicated that the contaminant should be considered for addition to the requested list of routine analytes for that well.

Table C1-3 presents the results of the evaluation of data for the priority (Phase I) COCs (carbon tetrachloride, chloroform, trichloroethylene [TCE], total chromium, arsenic, cadmium, strontium-90, iodine-129, technetium-99, uranium, tritium, and nitrate), as well as for the Phase II evaluation discussed below.

Phase II evaluated all analytical data reported for these same wells over the last 11 years. The same criteria listed above were used, and the contaminants in the database were compared against the regulatory limit. Of the contaminants listed in Table C1-2, the evaluation produced eight analytes (1,2 dichloroethane, benzene, methylene chloride, tetrachloroethylene, antimony, iron, fluoride, and manganese) that should be considered for including in the routine analyses for some wells. Table C1-4 presents the additional COCs that were evaluated in Phase II.

For several COCs, results are reported as nondetects (i.e., result is qualified with a "U"), but the reported value exceeded the MCL and/or background. Some of the COCs that show this behavior include antimony and selenium. The presence or absence of a low-level plume of these COCs cannot be established based on the data. The detection limits requested of the laboratory should be reviewed in light of the MCL for these COCs and consideration given to requiring a detection limit below the MCL.

Note that if a well has been routinely analyzed for a COCs and the data evaluation showed no recently detected data for that COC, it was still retained as a COC for that well.

C1.3.3 Results of the Evaluation of Data for Routinely Analyzed and Nonroutinely Analyzed Contaminants of Concern

In reviewing the results of the database query, the following analytes were found in the database but are not contaminants of potential concern or COCs, and/or no regulatory limits are available. These analytes include dichloro-diphenyl-dichloroethane, dichloro-diphenyl-dichloroethylene, dichloro-diphenyl-trichloroethane, and n-butylbenzene. Because the presence of these analytes will show up during volatile organic analysis, they were not specifically added to the list of routinely analyzed COCs.

Table C1-3. Results of Evaluation of Last 10 Years of Data for Wells in Table A3-2 for Routinely Analyzed Contaminants of Concern (Data from Virtual Database Search August 2003). (7 sheets)

Well Name	Carbon Tet.	Chloro-form	TCE	Chromium (Total)	As	Cd	Sr-90	I-129	Tc-99	Uranium	Tritium	Nitrate	Other COC[a]	Sampling Frequency
299-W6-10	X +	-	+	-	- '93	X -	- 2 DP '94	X -	-	X -	X +	X +		Annual
299-W7-4	X +	-	X -	-	- '96	-	- '92	-	-	-	-	X +		Annual
299-W7-12	X +	-	-	-	- '96	-	- '92	-	-	-	X -	X +		Biennial
299-W8-1	X +	-	-	-	-	-	-	-	-	-	X -	X +		Biennial
299-W10-1	X +	+	X +	X -	X -	-	ND	-	-	-	X -	X +		Annual
299-W10-4	X +	+	X +	X +	X -	-	ND	X -	X -	-	X -	X +	F +	Semi-annual
299-W10-5	X +	X +	X +	X -	- 2 DP '92	X -	ND	-	X -	-	X -	X +	See *footnote f* +	Annual
299-W10-13	X +	-	X -	-	- '96	-	- '92	-	-	-	-	X +		Biennial
299-W10-20	X +	+	X -	-	- '96	-	- '94	-	-	-	-	X +		Biennial
299-W10-21	X +	+	X +	-	- '96	X -	- 2 DP '94	-	-	-	X -	X +		Annual
299-W10-22	X +	-	X +	X -	ND	-	ND	X -	X -	X - 2 DP	X -	X +		Semi-annual
299-W10-23	X +	+	X +	X +	X - 1 DP	X -	-	X -	X -	X - 1 DP	X +	X +	F +	Annual

Table C1-3. Results of Evaluation of Last 10 Years of Data for Wells in Table A3-2 for Routinely Analyzed Contaminants of Concern (Data from Virtual Database Search August 2003). (7 sheets)

Well Name	Carbon Tet.	Chloro-form	TCE	Chromium (Total)	As	Cd	Sr-90	I-129	Tc-99	Uranium	Tritium	Nitrate	Other COC[e]	Sampling Frequency
299-W11-3	X +	-	X -	- '95	- 2 DP '92	- 2 DP '92	ND	X -	-	X -	X -	X +		Semi-annual
299-W11-6	X +	-	X -	- '95	- 2 DP '92	- 2 DP '92	ND	X -	-	X - 1 DP	-	X +		Semi-annual
299-W11-7	X +	X -	X +	X -	X - 1 DP	X -	ND	X -	X -	X -	-	X +		Annual
299-W11-10	X +	+	-	- '95	- 2 DP '92	- '95	ND	-	-	- 2 DP '95	-	X +		Semi-annual
299-W11-13	X +	X -	X -	X -	X - 2 DP	X -	ND	X -	X -	ND	X -	X +		Semi-annual
299-W11-14	NR +	NR +	NR +	- '95	- 2 DP '92	- 2 DP '92	- '98	NR -	-	NR +	NR +	NR + '98		Semi-annual
299-W11-18	X +	X +	X +	X -	- 2 DP '92	X -	- 2 DP '98	X -	X -	X -	X -	X +	See footnote f +	Annual
299-W11-37	X +	-	X -	-	ND	-	ND	X U	-	X +	X -	X +		Semi-annual
299-W12-1	X +	-	-	-	- 2 DP '92	-	ND	X -	-	-	X -	X +		Annual
299-W14-14	X +	X -	X -	X -	- 1 DP '98	X -	- '98	X -	X -	ND	X -	X +		Annual
299-14-16[a]	NR ND	ND	NR ND	NR -	ND	-	ND	NR -	NR -	ND	NR -	NR +		Annual

Table C1-3. Results of Evaluation of Last 10 Years of Data for Wells in Table A3-2 for Routinely Analyzed Contaminants of Concern (Data from Virtual Database Search August 2003). (7 sheets)

Well Name	Carbon Tet.	Chloro-form	TCE	Chromium (Total)	As	Cd	Sr-90	I-129	Tc-99	Uranium	Tritium	Nitrate	Other COC[c]	Sampling Frequency
299-W15-1	X +	X +	X +	ND	ND	ND	ND	ND	ND	-	- 1 DP '94	X + 1 DP		Semi-annual
299-W15-2	X +	X -	X -	-	- 2 DP '92	-	ND	-	X -	ND	-	X +		Annual
299-W15-7	X +	X +	X +	- '92	- '92	- '92	ND	- 2 DP '94	X -	- '94	-	X +		Semi-annual
299-W15-11	X +	X +	X +	- 1 DP '95	ND	ND	ND	-	X - 1 DP	ND	X -	X +		Semi-annual
299-W15-15	X +	X -	-	-	- '96	X -	- 2 DP '92	-	-	-	-	X +		Annual
299-W15-17[a]	NR +	NR -	NR -	NR -	- '96	NR -	- 2DP '92	-	-	-	-	NR +		Semi-annual
299-W15-30[b]	NR +	NR +	NR -	NR ND	ND	NR ND	ND	- 2 DP	NR[c] - 2 DP	ND	- 2 DP	NR ND		Semi-annual
299-W15-31A	X +	X +	X +	ND	ND	ND	ND	ND	ND	ND	ND	X +		Semi-annual
ND	X +	X +	X +	ND	ND	ND	ND	-	X -	ND	-	X +	MeCl +	Annual
299-W15-35	X +	X +	X +	X - 1 DP	ND	- 1 DP	ND	-	X -	ND	-	X +	MeCl +	Annual
299-W15-36	X +	X +	X +	ND	ND	ND	ND	- 1 DP	-	ND	- 1 DP	X +	MeCl +	Annual

Table C1-3. Results of Evaluation of Last 10 Years of Data for Wells in Table A3-2 for Routinely Analyzed Contaminants of Concern (Data from Virtual Database Search August 2003). (7 sheets)

Well Name	Carbon Tet.	Chloro-form	TCE	Chromium (Total)	As	Cd	Sr-90	I-129	Tc-99	Uranium	Tritium	Nitrate	Other COC[c]	Sampling Frequency
299-W15-38	X +	X +	X +	X - 1 DP	ND	- 1 DP	ND	ND	ND	ND	ND	X + 1 DP		Annual
299-W15-39	X +	X +	X +	ND	ND	ND	ND	ND	ND	ND	ND	X + 1 DP		Semi-annual
299-W15-40	X +	X +	X +	X -	- 1 DP '98	X -	ND	-	X -	ND	X -	X +		Semi-annual
299-W15-41	X +	X +	X +	-	ND	X -	-	-	X +	ND	X -	X +		Semi-annual
New well A (299-W15-42)[d]	X +	X +	X -	X -	ND	X -	-	ND	X -	ND	-	X +	Fe, MeCl +	Semi-annual
299-W15-43	NR +	NR +	NR +	-	ND	-	ND	ND	NR -	ND	X -	NR +	Mn +	Semi-annual
299-W15-44[a]	NR ND	NR ND	NR ND	-	ND	-	ND	NR - 2 DP	NR -	ND	X -	NR +	Mn +	Semi-annual
New well B (299-W15-45)[d]	X ND	X ND	X ND	ND	ND	ND	ND	ND	X ND	ND	ND	X ND		Quarterly
299-W18-1[a]	X +	X +	X -	-	ND	X -	ND	- 1 DP '93	ND	ND	-	X +		Semi-annual
299-W18-23[a]	NR +	NR -	-	-	- '96	-	- 2 DP '92	-	NR -	NR -	-	NR +		Semi-annual
299-W18-27	NR +	NR -	NR -	-	- '96	-	- '92	ND	- '92	NR -	-	NR -		Annual

Table C1-3. Results of Evaluation of Last 10 Years of Data for Wells in Table A3-2 for Routinely Analyzed Contaminants of Concern (Data from Virtual Database Search August 2003). (7 sheets)

Well Name	Carbon Tet.	Chloro-form	TCE	Chromium (Total)	As	Cd	Sr-90	I-129	Tc-99	Uranium	Tritium	Nitrate	Other COC[a]	*Sampling Frequency*
699-43-89	X -	X -	X -	X - 1 DP	X - 1 DP	X - 1 DP	X - 1 DP	X - 1 DP	X - 1 DP	X - 1 DP	X -	X +		Biennial
699-44-64	-	-	-	- 2 DP '92	- 2 DP '92	- 2 DP '92	ND	X -	X -	X -	X -	X +		Biennial
699-45-69A	X -	-	-	-	ND	-	ND	X -	-	-	-	X -		Biennial
699-47-60	X -	X -	X -	X -	- '95	-	- '95	X -	X -	X -	X -	X +		Biennial
699-48-71	X +	-	X -	-	- 2 DP '92	-	ND	X -	- '98	X -	X -	X +		Biennial
699-48-77A	X -	-	-	+	-	-	-	-	ND	-	X +	X -	Fe +	Biennial
699-55-60A	X -	X -	X -	X -	- 2 DP '92	-	ND	X -	X -	X - 1 DP	X -	X +		Biennial
New well C	X	X										X		Quarterly
New well D	X	X	X									X		Quarterly
New well E	X	X	X	X								X		Quarterly
New well F	X	X	X									X		Quarterly
New well G	X										X	X		Quarterly

Table C1-3. Results of Evaluation of Last 10 Years of Data for Wells in Table A3-2 for Routinely Analyzed Contaminants of Concern (Data from Virtual Database Search August 2003). (7 sheets)

Well Name	Carbon Tet.	Chloro-form	TCE	Chromium (Total)	As	Cd	Sr-90	I-129	Tc-99	Uranium	Tritium	Nitrate	Other COC[e]	Sampling Frequency
New well H	X		X					X		X	X	X		Quarterly
New well I	X	X	X						X		X	X		Quarterly
New well T	X										X	X		Quarterly

[a] *Resource Conservation and Recovery Act of 1976* well.
[b] Well 299-W15-30 supplements well 299-W15-16.
[c] Use technetium-99 as tracer.
[d] Recently installed and named.
[e] See specific metal or added COC in footnotes.
[f] 1,2-dichloroethane, benzene, tetrachloroethylene, and methylene chloride.
COC = contaminant of concern
DP = data point
MeCl = methylene chloride
ND = no data found
NR = new request for analysis based on data review
TCE = trichloroethylene
X = Denotes COCs that were previously selected for analysis (before data review). A "+" for a particular combination of well/analyte for which no analysis was previously requested will generate a new data request. See Table A3-2 (Appendix A) for the final selections.

Table C1-4. Results of Evaluation of Additional Reported Contaminants of Concern from Table A3-2 Wells (FH 2003b). (Data from Virtual Database Search June 2003). (3 sheets)

Well Name	1,2 Dichloro-ethane	Benzene	Methylene Chloride	Tetrachloro-ethylene	Sb	Fe	Mn	Fluoride
299-W6-2	-	-	-	-	-	-	-	-
299-W6-7	-	-	-	-	U '95	-	-	-
299-W6-10	-	-	-	-	U	-	-	-
299-W7-4	-	-	-	-	-	-	-	-
299-W7-7	-	-	-	-	+	+	-	-
299-W7-8	-	-	-	-	-	-	-	-
299-W7-12	-	-	-	-	-	-	-	-
299-W8-1	-	-	-	-	-	-	-	-
299-W10-1	-	-	-	-	-	-	-	-
299-W10-4	-	-	-	-	-	-	-	+
299-W10-5	+	+	+	+	-	-	-	-
299-W10-13	-	-	-	-	-	-	-	-
299-W10-19	-	-	-	-	-	-	-	-
299-W10-20	-	-	-	-	-	-	-	-
299-W10-21	-	-	-	-	-	-	-	-
299-W10-22	-	-	-	-	-	-	-	-
299-W10-23	-	-	-	-	-	-	-	+
299-W11-3	-	-	-	-	U '95	- '95	- '95	-
299-W11-6	-	-	-	-	U '95	- '95	- '95	-
299-W11-7	-	-	-	-	-	-	-	-
299-W11-10	-	-	-	-	U '95	- '95	- '95	-
299-W11-13	-	-	-	-	U	-	-	-
299-W11-14	-	-	-	-	U '95	- '95	- '95	- '98
299-W11-18	+	+	+	+	U	-	-	-
299-W11-37	-	-	-	-	-	-	-	-
299-W12-1	-	-	-	-	-	-	-	-
299-W14-14	-	-	-	-	-	-	-	-
299-W14-16	ND	ND	ND	ND	-	-	-	-
299-W15-1	-	-	-	-	ND	ND	ND	- 1 DP

Table C1-4. Results of Evaluation of Additional Reported Contaminants of Concern from Table A3-2 Wells (FH 2003b). (Data from Virtual Database Search June 2003). (3 sheets)

Well Name	1,2 Dichloro-ethane	Benzene	Methylene Chloride	Tetrachloro-ethylene	Sb	Fe	Mn	Fluoride
299-W15-2	-	-	-	-	-	-	-	-
299-W15-7	-	-	-	-	U '92	- '92	'92	-
299-W15-11	-	-	-	-	ND	- 1 DP '95	- 1 DP '95	-
299-W15-15	-	-	-	-	-	-	-	-
299-W15-16	-	-	-	-	-	-	-	-
299-W15-17	-	-	-	-	-	-	-	-
299-W15-30	U 1 DP '95	U 1 DP '95	+ 1 DP '95	- 1 DP '95	ND	ND	ND	ND
299-W15-31A	-	-	-	-	ND	ND	ND	- 1 DP
299-W15-32	-	-	+	-	-	-	-	-
299-W15-33	- 2 DP	- 2 DP	+	-	ND	ND	ND	- 1 DP
299-W15-34	-	-	+	-	ND	ND	ND	-
299-W15-35	- 2 DP	- 2 DP	+	-	U 1 DP	- 1 DP	- 1 DP	- 1 DP
299-W15-36	-	-	+	-	ND	ND	ND	-
299-W15-38	-	-	-	-	U 1 DP	- 1 DP	- 1 DP	- 1 DP
299-W15-39	-	-	-	-	ND	ND	ND	- 1 DP
299-W15-40	-	-	-	-	-	-	-	-
299-W15-41	-	-	-	-	-	-	-	-
New well A (299-W15-42)[b]	-	-	+	-	U	+	-	-
299-W15-43	-	-	-	-	U	-	+	-
299-15-44	ND	ND	ND	ND	U	-	+	-
New well B (299-W15-45)[b]	ND	ND	ND	ND	ND	ND	ND	ND
299-W15-46	ND	ND	ND	ND	ND	ND	ND	ND
299-W18-1	-	-	-	-	-	-	-	-
299-W18-23	-	-	-	-	-	-	-	-
299-W18-27	-	-	-	-	U	-	-	-

Table C1-4. Results of Evaluation of Additional Reported Contaminants of Concern from Table A3-2 Wells (FH 2003b). (Data from Virtual Database Search June 2003). (3 sheets)

Well Name	1,2 Dichloro-ethane	Benzene	Methylene Chloride	Tetrachloro-ethylene	Sb	Fe	Mn	Fluoride
699-39-79	-	-	-	-	U	-	-	-
699-43-89	-	-	-	-	U 1 DP	- 1 DP	- 1 DP	-
699-44-64	-	-	-	-	U 2 DP	- 2 DP '92	- 2 DP '92	-
699-45-69A	-	-	-	-	U	-	-	-
699-47-60	-	-	-	-	U	-	-	-
699-48-71	-	-	-	-	-	-	-	-
699-48-77A	-	-	-	-	U	+	-	-
699-55-60A	-	-	-	-	U	-	-	-
New well C								
New well D								
New well E								
New well F								
New well G								
New well H								
New well I								
New well T								

DP = data point
ND = no data found

The results of the evaluation are presented in the Tables C1-3 and C1-4. Table A3-2 in Appendix A is the current routine monitoring table based on the evaluation of results. The following analytes were added to specific wells based on the information in Tables C1-3 and C1-4. As noted above, routine analytes (carbon tetrachloride, chloroform, TCE, total chromium, arsenic, cadmium, strontium-90, iodine-129, technetium-99, uranium, tritium, and nitrate) were added to specific wells based on whether or not they were historically found in the wells at sufficient frequencies based on the logic in Figure 3-1 (see main text of this work plan); however, these analytes were never deleted from wells based on this logic. Nonroutine analytes (antimony, iron, manganese, fluoride, 1,2-dichloroethane, benzene, tetrachloroethylene, and methylene chloride) were added if found in the wells at sufficient frequencies based on the logic in Figure 3-1.

- 1,2-dichloroethane, benzene, methylene chloride, and tetrachloroethylene were added to wells 299-W10-5 and 299-W11-18.

- In addition to the wells specified above, methylene chloride was added to wells 299-W15-32, 299-W15-33, 299-W15-34, 299-W15-35, and 299-W15-36 and to new well 299-W15-42.
- Both antimony and iron were added to well 299-W7-7.
- In addition, iron was added to wells 299-W15-42 and 699-48-77A.
- Manganese was added to wells 299-W15-43 and 299-W15-44.
- Fluoride was added to wells 299-W10-4 and 299-W10-23.
- Chloroform was added to wells 299-W10-1, 299-W10-4, 299-W10-20, 299-W10-21, 299-W10-23, 299-W11-10, 299-W10-1, and 299-W10-1.
- TCE was added to well 299-W6-10.
- For wells 299-W7-7 and 699-48-77A, chromium was found above the MCL and was added.

Table A3-2 in Appendix A provides a summary of recommendations resulting from the data evaluation.

C1.4 MINIMUM, MAXIMUM, AVERAGE, AND STANDARD DEVIATION OF MONITORING RESULTS FOR THE 200-ZP-1 GROUNDWATER MONITORING WELL NETWORK

Table C1-5 lists the minimum, maximum, and average concentrations for constituents in Table C1-3 and C1-4. Data were obtained from the Virtual Library database for the period from January 1992 through August 2003. The following information defines how the minimum, maximum, average, and standard deviation were calculated in the database:

- **Min:** Uses the structured query language (SQL) language function "MIN" to calculate and report the "minimum" result for all results that do not contain the flag "U" in the laboratory qualifier field for the identified constituent and filter flag.
- **Max:** Uses the SQL language function "MAX" to calculate and report the "maximum" of the results that do not contain the flag "U" in the laboratory qualifier field for the identified constituent and filter flag.
- **Avg:** Calculated field for average value for results; where a given analyte was detected.
- **StDev:** Uses the SQL language function "STDEV" to calculate and report the standard deviation of the results that do not contain the flag "U" in the laboratory qualifier field for the identified constituent and filter flag.

Section C1.5 summarizes the evaluation of the data in Table C1-5.

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
Carbon Tetrachloride								
299-W10-1	N	µg/L	13	12	38.00	1,700.00	931.50	530.96
299-W10-13	N	µg/L	27	27	1.00	20.00	11.87	5.18
299-W10-19	N	µg/L	27	27	37.00	1,800.00	775.59	630.96
299-W10-20	N	µg/L	31	31	62.00	2,700.00	1,564.58	664.99
299-W10-21	N	µg/L	32	31	76.00	660.00	465.03	132.98
299-W10-22	N	µg/L	4	4	380.00	910.00	637.50	226.18
299-W10-23	N	µg/L	5	5	1,500.00	1,600.00	1,560.00	54.77
299-W10-4	N	µg/L	13	13	570.00	2,200.00	1,492.31	480.37
299-W10-5	N	µg/L	8	8	820.00	2,600.00	1,828.75	679.90
299-W11-10	N	µg/L	11	11	560.00	1,300.00	920.00	263.67
299-W11-13	N	µg/L	3	3	270.00	420.00	366.67	83.86
299-W11-14	N	µg/L	12	12	440.00	1,500.00	976.00	365.06
299-W11-18	N	µg/L	13	13	340.00	540.00	462.38	60.78
299-W11-3	N	µg/L	10	10	340.00	570.00	456.00	76.48
299-W11-37	Y	µg/L	2	2	310.00	330.00	320.00	14.14
299-W11-37	N	µg/L	2	2	230.00	550.00	390.00	226.27
299-W11-6	N	µg/L	11	11	51.00	1,500.00	491.00	406.45
299-W11-7	N	µg/L	10	10	230.00	1,400.00	1,008.00	361.10
299-W12-1	N	µg/L	16	14	7.00	140.00	54.93	55.78
299-W14-14	N	µg/L	12	12	140.00	920.00	430.00	272.10
299-W15-1	N	µg/L	39	39	1,180.00	7,900.00	4,234.03	1,781.60
299-W15-11	N	µg/L	45	45	1.00	5,000.00	2,684.78	1,101.86
299-W15-15	N	µg/L	60	60	25.00	1,900.00	590.27	532.79
299-W15-16	N	µg/L	42	42	900.00	7871.00	3,997.95	1,861.50
299-W15-17	N	µg/L	24	24	0.40	15.00	5.63	4.64
299-W15-2	N	µg/L	7	7	23.00	120.00	69.29	35.20
299-W15-30	N	µg/L	19	19	2,400.00	7,100.00	5,186.32	1,365.04
299-W15-31A	N	µg/L	41	40	2,500.00	7,500.00	5,213.45	1,294.79
299-W15-32	N	µg/L	181	181	790.00	8,200.00	4,219.52	1,715.97
299-W15-33	N	µg/L	221	221	1,900.00	7,200.00	5,176.54	1,159.61
299-W15-34	N	µg/L	244	244	600.00	6,900.00	4,263.03	1,216.88
299-W15-35	N	µg/L	243	243	160.00	5,400.00	3,394.64	620.77
299-W15-36	N	µg/L	190	190	370.00	3,700.00	1,569.34	502.55
299-W15-38	N	µg/L	46	46	510.00	4,000.00	2,407.39	813.12
299-W15-39	N	µg/L	31	30	390.00	2,500.00	1,058.93	433.33
299-W15-40	N	µg/L	5	5	950.00	3,400.00	2,410.00	909.95
299-W15-41	N	µg/L	5	5	630.00	1,400.00	1,030.00	316.39
299-W15-42	Y	µg/L	4	4	110.00	2,800.00	872.50	1,288.21
299-W15-42	N	µg/L	11	11	46.00	1,800.00	1,233.27	538.33
299-W15-43	N	µg/L	8	8	0.85	3,300.00	1,912.61	1,099.71
299-W15-7	N	µg/L	58	57	3.00	4,900.00	2,297.16	1,216.49
299-W18-1	Y	µg/L	1	0				
299-W18-1	N	µg/L	37	36	110.00	4,100.00	1,250.36	979.77
299-W18-23	N	µg/L	37	37	43.00	710.00	320.84	195.30
299-W18-27	N	µg/L	45	44	4.60	550.00	282.49	116.70

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W6-10	N	µg/L	15	15	31.00	1,300.00	734.07	337.23
299-W6-2	N	µg/L	25	25	58.00	190.00	113.80	35.87
299-W6-7	N	µg/L	14	14	16.00	300.00	166.36	87.96
299-W7-12	N	µg/L	29	24	0.70	4.70	1.98	1.23
299-W7-4	N	µg/L	27	27	190.00	740.00	485.56	144.92
299-W7-7	N	µg/L	29	29	1.10	22.00	5.04	4.84
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	23	16	0.50	12.00	5.84	3.77
299-W8-1	N	µg/L	44	43	1.00	6.40	4.06	1.25
699-39-79	N	µg/L	40	24	2.00	887.00	416.69	317.56
699-43-89	N	µg/L	5	2	0.15	0.34	0.25	0.13
699-44-64	N	µg/L	6	5	1.00	2.30	1.76	0.51
699-45-69A	N	µg/L	9	8	0.40	0.80	0.63	0.12
699-47-60	N	µg/L	14	0				
699-48-71	N		1	0				
699-48-71	N	µg/L	12	8	0.23	9.90	3.62	3.98
699-48-77A	Y	µg/L	2	0				
699-48-77A	N	µg/L	57	5	0.26	5.00	2.39	2.41
699-55-60A	N	µg/L	5	0				
Chloroform								
299-W10-1	N	µg/L	13	11	6.00	16.00	9.43	3.44
299-W10-13	N	µg/L	27	21	0.09	2.30	0.52	0.47
299-W10-19	N	µg/L	27	25	1.70	50.00	12.20	11.69
299-W10-20	N	µg/L	31	31	2.70	76.00	32.70	22.53
299-W10-21	N	µg/L	32	32	2.00	200.00	15.02	34.34
299-W10-22	N	µg/L	4	4	4.70	6.40	5.62	0.85
299-W10-23	N	µg/L	5	5	11.00	14.00	12.40	1.14
299-W10-4	N	µg/L	13	13	11.00	16.00	13.23	1.48
299-W10-5	N	µg/L	8	8	11.00	37.00	18.00	8.30
299-W11-10	N	µg/L	11	11	4.00	10.00	7.19	1.82
299-W11-13	N	µg/L	3	3	4.90	5.10	5.00	0.10
299-W11-14	N	µg/L	12	11	3.00	12.00	6.65	2.95
299-W11-18	N	µg/L	13	13	2.80	12.00	5.56	3.40
299-W11-3	N	µg/L	10	10	1.70	12.00	3.57	3.03
299-W11-37	Y	µg/L	2	2	3.20	4.60	3.90	0.99
299-W11-37	N	µg/L	2	2	3.30	4.00	3.65	0.49
299-W11-6	N	µg/L	11	11	2.60	12.00	4.96	2.87
299-W11-7	N	µg/L	10	9	5.70	9.00	7.27	1.16
299-W12-1	N	µg/L	16	15	1.00	4.90	2.47	1.37
299-W14-14	N	µg/L	12	12	3.90	25.00	8.29	6.41
299-W15-1	N	µg/L	39	36	10.00	46.00	25.36	7.18
299-W15-11	N	µg/L	45	42	2.00	100.00	23.60	14.31
299-W15-15	N	µg/L	60	35	0.23	20.00	5.04	5.01
299-W15-16	N	µg/L	42	39	0.40	50.00	24.25	10.67
299-W15-17	N	µg/L	24	22	0.21	2.20	1.59	0.57
299-W15-2	N	µg/L	7	7	1.00	2.10	1.39	0.45
299-W15-30	N	µg/L	19	19	12.00	1,100.00	116.84	241.12

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-31A	N	µg/L	41	39	15.00	180.00	46.18	28.05
299-W15-32	N	µg/L	181	174	14.00	69.00	28.38	9.82
299-W15-33	N	µg/L	220	212	10.00	35.00	22.79	4.76
299-W15-34	N	µg/L	243	237	2.80	37.00	19.02	4.89
299-W15-35	N	µg/L	242	235	2.00	40.00	17.41	3.07
299-W15-36	N	µg/L	189	185	13.00	38.00	21.78	3.49
299-W15-38	N	µg/L	46	44	14.00	110.00	27.80	14.60
299-W15-39	N	µg/L	31	29	12.00	250.00	23.79	43.61
299-W15-40	N	µg/L	5	5	10.00	44.00	19.00	14.14
299-W15-41	N	µg/L	5	5	5.60	12.00	7.60	2.54
299-W15-42	Y	µg/L	4	4	9.00	270.00	86.50	123.61
299-W15-42	N	µg/L	11	11	14.00	680.00	140.45	257.19
299-W15-43	N	µg/L	8	7	12.00	29.00	18.14	7.15
299-W15-7	N	µg/L	58	55	12.00	110.00	40.87	26.90
299-W18-1	Y	µg/L	1	0				
299-W18-1	N	µg/L	37	28	1.00	43.00	16.34	11.45
299-W18-23	N	µg/L	37	31	0.38	40.00	3.70	7.00
299-W18-27	N	µg/L	45	21	0.40	20.00	5.70	6.38
299-W6-10	N	µg/L	15	14	0.40	120.00	14.31	30.58
299-W6-2	N	µg/L	25	23	0.71	20.00	2.47	3.88
299-W6-7	N	µg/L	14	14	0.95	8.70	4.17	2.47
299-W7-12	N	µg/L	29	23	0.20	3.80	0.74	0.69
299-W7-4	N	µg/L	27	26	4.50	20.00	7.40	3.23
299-W7-7	N	µg/L	29	23	0.05	1.80	0.71	0.48
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	23	15	0.19	1.30	0.62	0.38
299-W8-1	N	µg/L	44	25	0.06	1.50	0.49	0.25
699-39-79	N	µg/L	40	16	2.00	46.00	12.70	9.81
699-43-89	N	µg/L	5	1	0.20	0.20	0.20	
699-44-64	N	µg/L	6	4	0.54	0.82	0.69	0.14
699-45-69A	N	µg/L	9	9	2.70	4.10	3.49	0.50
699-47-60	N	µg/L	14	0				
699-48-71	N	µg/L	13	12	0.95	2.10	1.68	0.45
699-48-77A	Y	µg/L	2	0				
699-48-77A	N	µg/L	60	4	0.16	5.00	2.65	2.72
699-55-60A	N	µg/L	5	1	0.26	0.26	0.26	

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
				TCE				
299-W10-1	N	µg/L	13	10	3.00	13.00	7.94	3.71
299-W10-13	N	µg/L	26	2	0.20	0.40	0.30	0.14
299-W10-19	N	µg/L	26	17	0.33	16.00	5.07	4.31
299-W10-20	N	µg/L	31	31	0.30	100.00	16.11	29.35
299-W10-21	N	µg/L	31	30	0.79	50.00	10.10	13.62
299-W10-22	N	µg/L	4	4	3.80	6.00	5.17	0.97
299-W10-23	N	µg/L	5	5	9.60	12.00	10.92	1.11
299-W10-4	N	µg/L	13	13	9.30	25.00	14.48	4.08
299-W10-5	N	µg/L	8	7	5.50	14.00	9.71	2.84
299-W11-10	N	µg/L	11	10	0.90	3.00	2.01	0.58
299-W11-13	N	µg/L	3	3	1.70	3.90	3.13	1.24
299-W11-14	N	µg/L	11	10	1.00	13.00	6.64	4.72
299-W11-18	N	µg/L	12	12	4.20	8.00	6.05	1.11
299-W11-3	N	µg/L	10	7	0.50	8.00	1.65	2.80
299-W11-37	Y	µg/L	2	2	1.70	3.20	2.45	1.06
299-W11-37	N	µg/L	2	2	1.90	2.40	2.15	0.35
299-W11-6	N	µg/L	11	11	0.40	8.00	1.84	2.13
299-W11-7	N	µg/L	10	9	3.60	20.00	7.13	4.97
299-W12-1	N	µg/L	1	0				
299-W12-1	N	µg/L	15	4	0.22	0.45	0.31	0.10
299-W14-14	N	µg/L	12	12	0.40	10.00	3.95	4.18
299-W15-1	N	µg/L	39	34	3.10	21.00	12.96	4.93
299-W15-11	N	µg/L	45	36	2.90	8.30	4.75	1.33
299-W15-15	N	µg/L	59	13	0.20	20.00	6.32	8.86
299-W15-16	N	µg/L	42	34	0.77	50.00	5.53	8.07
299-W15-17	N	µg/L	24	16	0.16	1.40	0.80	0.45
299-W15-2	N	µg/L	7	0				
299-W15-30	N	µg/L	19	15	3.30	10.00	7.04	1.95
299-W15-31A	N	µg/L	41	36	3.00	12.00	6.26	2.01
299-W15-32	N	µg/L	181	169	0.50	10.00	4.73	1.19
299-W15-33	N	µg/L	221	209	2.00	17.80	7.45	2.80
299-W15-34	N	µg/L	244	230	2.10	19.00	11.55	2.47
299-W15-35	N	µg/L	243	228	2.30	16.00	7.36	2.38
299-W15-36	N	µg/L	190	179	1.90	15.00	5.48	3.02
299-W15-38	N	µg/L	46	21	2.00	6.80	3.95	1.34
299-W15-39	N	µg/L	31	7	2.00	4.00	2.96	0.78
299-W15-40	N	µg/L	5	5	12.00	16.00	14.00	1.58
299-W15-41	N	µg/L	5	5	2.30	8.00	5.32	2.49
299-W15-42	Y	µg/L	4	1	3.00	3.00	3.00	
299-W15-42	N	µg/L	11	8	2.00	2.80	2.45	0.33
299-W15-43	N	µg/L	8	7	2.60	7.30	5.10	1.85
299-W15-7	N	µg/L	58	39	2.00	33.00	17.32	7.54
299-W18-1	Y	µg/L	1	0				
299-W18-1	N	µg/L	37	8	0.43	8.00	5.19	2.67
299-W18-23	N	µg/L	37	11	0.17	40.00	6.16	12.69
299-W18-27	N	µg/L	45	10	0.09	20.00	2.63	6.22

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W6-10	N	µg/L	15	14	1.00	32.00	12.69	7.25
299-W6-2	N	µg/L	24	19	0.60	4.00	1.51	0.83
299-W6-7	N	µg/L	14	12	0.59	5.30	2.71	1.50
299-W7-12	N	µg/L	28	1	2.90	2.90	2.90	
299-W7-4	N	µg/L	26	21	0.60	15.00	2.95	3.36
299-W7-7	N	µg/L	27	6	0.07	0.33	0.24	0.10
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	22	3	0.15	0.16	0.16	0.01
299-W8-1	N	µg/L	43	0				
699-39-79	N		2	0				
699-39-79	N	µg/L	38	6	0.18	0.80	0.50	0.21
699-43-89	N	µg/L	5	1	0.25	0.25	0.25	
699-44-64	N	µg/L	6	6	3.00	4.00	3.63	0.37
699-45-69A	N		1	0				
699-45-69A	N	µg/L	8	1	0.09	0.09	0.09	
699-47-60	N	µg/L	14	1	0.50	0.50	0.50	
699-48-71	N		1	0				
699-48-71	N	µg/L	12	0				
699-48-77A	Y	µg/L	2	0				
699-48-77A	N		1	0				
699-48-77A	N	µg/L	55	2	5.00	5.00	5.00	0.00
699-55-60A	N	µg/L	5	0				
				Chromium				
299-W10-1	Y	µg/L	19	19	18.40	263.00	56.99	75.62
299-W10-1	N	µg/L	1	1	264.00	264.00	264.00	
299-W10-13	Y	µg/L	27	15	3.70	30.00	8.23	6.50
299-W10-13	N	µg/L	10	10	20.00	330.00	133.70	101.35
299-W10-19	Y	µg/L	26	23	5.40	26.00	13.73	5.05
299-W10-19	N	µg/L	8	8	20.00	80.00	43.13	21.64
299-W10-20	Y	µg/L	28	26	5.70	21.00	11.28	3.24
299-W10-20	N	µg/L	8	8	7.80	64.00	25.99	20.02
299-W10-21	Y	µg/L	21	21	21.80	40.50	28.49	5.04
299-W10-21	N	µg/L	4	4	33.00	69.00	45.25	16.38
299-W10-22	Y	µg/L	24	22	4.30	62.00	32.88	20.39
299-W10-23	Y	µg/L	20	20	79.80	153.00	110.42	25.06
299-W10-4	Y	µg/L	27	27	41.80	332.00	185.10	73.38
299-W10-4	N	µg/L	3	3	44.30	49.10	46.83	2.41
299-W10-5	Y	µg/L	6	6	4.00	19.50	12.63	5.28
299-W10-5	N	µg/L	1	1	35.20	35.20	35.20	
299-W11-10	Y	µg/L	3	3	9.30	13.00	10.57	2.11
299-W11-10	N	µg/L	1	1	38.10	38.10	38.10	
299-W11-13	Y	µg/L	3	3	4.50	10.00	7.10	2.76
299-W11-14	Y	µg/L	3	2	7.90	8.60	8.25	0.49
299-W11-14	N	µg/L	1	1	12.00	12.00	12.00	
299-W11-18	Y	µg/L	5	5	21.10	69.90	37.60	18.78
299-W11-18	N	µg/L	1	1	25.90	25.90	25.90	
299-W11-3	Y		2	0				

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W11-3	Y	µg/L	1	0				
299-W11-3	N	µg/L	1	0				
299-W11-37	Y	µg/L	3	3	14.20	28.30	20.57	7.15
299-W11-6	Y	µg/L	3	2	5.20	5.60	5.40	0.28
299-W11-6	N	µg/L	1	1	17.20	17.20	17.20	
299-W11-7	Y	µg/L	13	13	6.70	19.00	11.26	3.34
299-W12-1	Y	µg/L	8	8	37.50	64.00	49.18	9.90
299-W12-1	N	µg/L	1	1	63.50	63.50	63.50	
299-W14-14	Y	µg/L	25	6	1.90	6.30	3.65	1.63
299-W14-16	Y	µg/L	11	3	2.70	3.50	3.10	0.40
299-W15-11	Y	µg/L	1	1	8.00	8.00	8.00	
299-W15-15	Y	µg/L	24	21	4.40	11.60	8.26	2.02
299-W15-15	N	µg/L	6	5	29.00	290.00	104.20	110.02
299-W15-16	Y	µg/L	23	18	5.70	20.00	9.80	3.42
299-W15-16	N	µg/L	6	6	77.00	140.00	97.67	24.65
299-W15-17	Y	µg/L	22	16	4.20	12.00	7.36	2.02
299-W15-17	N	µg/L	6	6	31.00	270.00	176.83	87.91
299-W15-2	Y	µg/L	4	0				
299-W15-2	N	µg/L	1	0				
299-W15-32	Y	µg/L	7	4	3.90	7.40	5.43	1.59
299-W15-35	Y	µg/L	1	1	4.70	4.70	4.70	
299-W15-38	Y	µg/L	1	1	4.30	4.30	4.30	
299-W15-40	Y	µg/L	18	16	5.30	18.00	12.86	2.92
299-W15-41	Y	µg/L	15	14	4.00	35.20	9.62	7.60
299-W15-42	Y	µg/L	5	4	6.00	7.70	7.08	0.81
299-W15-42	N	µg/L	3	2	6.50	7.30	6.90	0.57
299-W15-43	Y	µg/L	8	4	7.00	17.00	10.88	4.60
299-W15-44	Y	µg/L	9	2	8.10	12.10	10.10	2.83
299-W15-7	Y	µg/L	1	0				
299-W15-7	N	µg/L	3	0				
299-W18-1	Y	µg/L	5	5	6.00	8.40	7.50	0.94
299-W18-23	Y	µg/L	24	15	2.40	8.60	4.99	1.38
299-W18-23	N	µg/L	6	6	20.00	210.00	73.00	73.37
299-W18-27	Y	µg/L	18	6	3.20	8.60	5.43	1.96
299-W18-27	N	µg/L	9	9	41.00	380.00	223.44	92.62
299-W6-10	Y	µg/L	24	24	34.60	60.00	46.20	9.02
299-W6-10	N	µg/L	6	6	65.00	97.00	78.33	12.97
299-W6-2	Y	µg/L	25	24	14.00	50.00	23.94	6.78
299-W6-2	N	µg/L	12	12	50.00	280.00	122.08	64.18
299-W6-7	Y	µg/L	11	11	49.00	85.00	64.64	11.26
299-W6-7	N	µg/L	9	9	91.00	360.00	194.56	92.61
299-W7-12	Y	µg/L	29	16	5.00	9.40	7.04	1.30
299-W7-12	N	µg/L	10	10	69.00	330.00	185.90	82.65
299-W7-4	Y	µg/L	27	22	7.80	40.00	11.57	6.57
299-W7-4	N	µg/L	10	10	30.00	230.00	102.30	51.83
299-W7-7	Y	µg/L	32	24	4.30	116.00	14.09	22.02
299-W7-7	N	µg/L	14	14	30.00	400.00	195.07	117.21

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W7-8	Y	µg/L	24	18	4.30	28.80	13.43	5.49
299-W7-8	N	µg/L	10	10	120.00	300.00	247.00	58.13
299-W8-1	Y	µg/L	42	31	3.40	18.00	6.97	2.94
299-W8-1	N	µg/L	25	25	10.20	170.00	53.09	49.21
699-39-79	Y	µg/L	2	1	6.10	6.10	6.10	
699-39-79	N	µg/L	1	0				
699-43-89	Y	µg/L	1	1	3.10	3.10	3.10	
699-44-64	Y	µg/L	1	0				
699-44-64	N	µg/L	1	0				
699-45-69A	Y	µg/L	3	1	2.60	2.60	2.60	
699-47-60	Y	µg/L	9	1	4.60	4.60	4.60	
699-47-60	N	µg/L	8	2	4.80	11.20	8.00	4.53
699-48-71	Y	µg/L	3	3	9.10	14.10	11.17	2.61
699-48-71	N	µg/L	2	0				
699-48-77A	Y	µg/L	51	40	0.60	21.00	4.19	4.30
699-48-77A	N	µg/L	54	53	5.00	450.00	48.64	69.06
699-55-60A	Y		1	0				
699-55-60A	Y	µg/L	2	0				
699-55-60A	N		1	0				
699-55-60A	N	µg/L	1	0				
Arsenic								
299-W10-1	Y	µg/L	2	0				
299-W10-1	N	µg/L	1	0				
299-W10-13	Y	µg/L	9	2	2.00	2.10	2.05	0.07
299-W10-13	N	µg/L	8	2	2.00	2.00	2.00	0.00
299-W10-19	Y	µg/L	7	4	2.00	2.00	2.00	0.00
299-W10-19	N	µg/L	6	3	2.00	2.00	2.00	0.00
299-W10-20	Y	µg/L	7	2	2.00	3.10	2.55	0.78
299-W10-20	N	µg/L	6	1	2.00	2.00	2.00	
299-W10-21	Y	µg/L	5	3	2.00	2.60	2.20	0.35
299-W10-21	N	µg/L	4	4	2.00	2.70	2.17	0.35
299-W10-23	Y	µg/L	1	1	2.00	2.00	2.00	
299-W10-4	Y	µg/L	4	4	3.80	10.40	6.58	2.77
299-W10-4	N	µg/L	3	3	7.80	10.10	8.93	1.15
299-W10-5	Y	µg/L	1	0				
299-W10-5	N	µg/L	1	0				
299-W11-10	Y	µg/L	1	1	2.20	2.20	2.20	
299-W11-10	N	µg/L	1	1	3.70	3.70	3.70	
299-W11-13	Y	µg/L	2	1	1.40	1.40	1.40	
299-W11-14	Y	µg/L	1	1	2.00	2.00	2.00	
299-W11-14	N	µg/L	1	1	2.10	2.10	2.10	
299-W11-18	Y	µg/L	1	1	2.30	2.30	2.30	
299-W11-18	N	µg/L	1	1	3.00	3.00	3.00	
299-W11-3	Y	µg/L	1	0				
299-W11-3	N	µg/L	1	0				
299-W11-6	Y	µg/L	1	0				
299-W11-6	N	µg/L	1	0				

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W11-7	Y	µg/L	1	1	1.80	1.80	1.80	
299-W12-1	Y	µg/L	1	1	2.00	2.00	2.00	
299-W12-1	N	µg/L	1	1	2.00	2.00	2.00	
299-W14-14	Y	µg/L	1	0				
299-W15-15	Y	µg/L	4	0				
299-W15-15	N	µg/L	3	0				
299-W15-16	Y	µg/L	4	0				
299-W15-16	N	µg/L	3	0				
299-W15-17	Y	µg/L	4	0				
299-W15-17	N	µg/L	3	0				
299-W15-2	Y	µg/L	1	0				
299-W15-2	N	µg/L	1	1	2.10	2.10	2.10	
299-W15-40	Y	µg/L	1	0				
299-W15-7	Y	µg/L	1	1	2.60	2.60	2.60	
299-W15-7	N	µg/L	3	1	3.30	3.30	3.30	
299-W18-23	Y	µg/L	4	1	2.60	2.60	2.60	
299-W18-23	N	µg/L	3	0				
299-W18-27	Y	µg/L	7	1	2.00	2.00	2.00	
299-W18-27	N	µg/L	6	1	2.00	2.00	2.00	
299-W6-10	Y	µg/L	4	1	2.00	2.00	2.00	
299-W6-10	N	µg/L	4	1	2.00	2.00	2.00	
299-W6-2	Y	µg/L	12	5	2.00	4.20	2.64	0.92
299-W6-2	N	µg/L	11	3	2.00	4.00	2.67	1.15
299-W6-7	Y	µg/L	7	0				
299-W6-7	N	µg/L	7	0				
299-W7-12	Y	µg/L	9	3	2.00	3.50	2.50	0.87
299-W7-12	N	µg/L	8	3	1.00	3.00	2.00	1.00
299-W7-4	Y	µg/L	9	4	2.00	4.40	3.32	1.12
299-W7-4	N	µg/L	8	3	2.90	3.00	2.97	0.06
299-W7-7	Y	µg/L	10	4	2.00	3.40	2.83	0.66
299-W7-7	N	µg/L	9	3	2.00	2.90	2.40	0.46
299-W7-8	Y	µg/L	9	4	2.00	3.10	2.55	0.47
299-W7-8	N	µg/L	8	2	2.00	2.00	2.00	0.00
299-W8-1	Y	µg/L	25	18	0.60	3.40	2.00	0.61
299-W8-1	N	µg/L	24	17	1.47	2.60	1.95	0.33
699-39-79	Y	µg/L	1	0				
699-39-79	N	µg/L	1	0				
699-43-89	Y	µg/L	1	1	2.00	2.00	2.00	
699-44-64	Y	µg/L	1	0				
699-44-64	N	µg/L	1	0				
699-47-60	Y	µg/L	8	8	5.40	7.60	6.64	0.77
699-47-60	N	µg/L	8	8	2.80	7.60	5.88	1.46
699-48-71	N	µg/L	2	0				
699-48-77A	Y	µg/L	50	43	1.00	7.19	4.52	1.93
699-48-77A	N	µg/L	51	44	1.00	7.25	4.60	1.97
699-55-60A	Y	µg/L	1	1	4.80	4.80	4.80	
699-55-60A	N	µg/L	1	1	3.50	3.50	3.50	

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
Cadmium								
299-W10-1	Y		1	0				
299-W10-1	Y	µg/L	18	1	1.40	1.40	1.40	
299-W10-1	N	µg/L	1	0				
299-W10-13	Y	µg/L	27	2	2.90	4.20	3.55	0.92
299-W10-13	N	µg/L	10	0				
299-W10-19	Y	µg/L	26	2	2.90	4.20	3.55	0.92
299-W10-19	N	µg/L	8	0				
299-W10-20	Y	µg/L	28	3	1.10	4.20	2.93	1.63
299-W10-20	N	µg/L	8	0				
299-W10-21	Y	µg/L	21	2	4.20	5.70	4.95	1.06
299-W10-21	N	µg/L	4	1	3.50	3.50	3.50	
299-W10-22	Y	µg/L	24	3	0.18	4.70	2.56	2.27
299-W10-23	Y	µg/L	20	0				
299-W10-4	Y	µg/L	27	0				
299-W10-4	N	µg/L	3	0				
299-W10-5	Y	µg/L	6	0				
299-W10-5	N	µg/L	1	0				
299-W11-10	Y		2	0				
299-W11-10	Y	µg/L	1	0				
299-W11-10	N	µg/L	1	0				
299-W11-13	Y	µg/L	3	0				
299-W11-14	Y		2	0				
299-W11-14	Y	µg/L	1	0				
299-W11-14	N	µg/L	1	0				
299-W11-18	Y		3	0				
299-W11-18	Y	µg/L	2	0				
299-W11-18	N	µg/L	1	0				
299-W11-3	Y		2	0				
299-W11-3	Y	µg/L	1	0				
299-W11-3	N	µg/L	1	0				
299-W11-37	Y	µg/L	3	0				
299-W11-6	Y		2	0				
299-W11-6	Y	µg/L	1	0				
299-W11-6	N	µg/L	1	0				
299-W11-7	Y		2	0				
299-W11-7	Y	µg/L	11	0				
299-W12-1	Y		1	0				
299-W12-1	Y	µg/L	7	0				
299-W12-1	N	µg/L	1	0				
299-W14-14	Y	µg/L	25	0				
299-W14-16	Y	µg/L	11	0				
299-W15-11	Y		1	0				
299-W15-15	Y	µg/L	24	1	4.00	4.00	4.00	
299-W15-15	N	µg/L	6	0				
299-W15-16	Y	µg/L	23	0				
299-W15-16	N	µg/L	6	0				

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-17	Y	µg/L	22	1	6.20	6.20	6.20	
299-W15-17	N	µg/L	6	0				
299-W15-2	Y	µg/L	4	0				
299-W15-2	N	µg/L	1	0				
299-W15-32	Y	µg/L	7	2	1.70	2.90	2.30	0.85
299-W15-35	Y	µg/L	1	0				
299-W15-38	Y	µg/L	1	0				
299-W15-40	Y	µg/L	18	0				
299-W15-41	Y	µg/L	15	0				
299-W15-42	Y	µg/L	5	0				
299-W15-42	N	µg/L	3	0				
299-W15-43	Y	µg/L	8	0				
299-W15-44	Y	µg/L	9	0				
299-W15-7	Y	µg/L	1	0				
299-W15-7	N	µg/L	3	0				
299-W18-1	Y	µg/L	5	0				
299-W18-23	Y	µg/L	24	0				
299-W18-23	N	µg/L	6	0				
299-W18-27	Y	µg/L	18	1	328.00	328.00	328.00	
299-W18-27	N	µg/L	9	0				
299-W6-10	Y	µg/L	24	1	7.30	7.30	7.30	
299-W6-10	N	µg/L	6	0				
299-W6-2	Y	µg/L	25	1	3.40	3.40	3.40	
299-W6-2	N	µg/L	12	0				
299-W6-7	Y	µg/L	11	0				
299-W6-7	N	µg/L	9	0				
299-W7-12	Y	µg/L	29	1	4.20	4.20	4.20	
299-W7-12	N	µg/L	10	0				
299-W7-4	Y	µg/L	27	2	2.00	3.00	2.50	0.71
299-W7-4	N	µg/L	10	0				
299-W7-7	Y	µg/L	32	2	4.20	5.00	4.60	0.57
299-W7-7	N	µg/L	14	0				
299-W7-8	Y	µg/L	24	2	3.40	4.20	3.80	0.57
299-W7-8	N	µg/L	10	0				
299-W8-1	Y	µg/L	42	4	0.11	4.20	1.34	1.92
299-W8-1	N	µg/L	25	2	0.29	0.50	0.39	0.15
699-39-79	Y	µg/L	2	0				
699-39-79	N	µg/L	1	0				
699-43-89	Y	µg/L	1	0				
699-44-64	Y	µg/L	1	0				
699-44-64	N	µg/L	1	0				
699-45-69A	Y	µg/L	3	0				
699-47-60	Y	µg/L	9	0				
699-47-60	N	µg/L	8	0				
699-48-71	Y	µg/L	3	0				
699-48-71	N	µg/L	2	0				
699-48-77A	Y	µg/L	55	6	0.04	1.09	0.44	0.42

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
699-48-77A	N	µg/L	58	5	0.04	3.60	0.90	1.52
699-55-60A	Y		1	0				
699-55-60A	Y	µg/L	2	0				
699-55-60A	N		1	0				
699-55-60A	N	µg/L	1	0				
Strontium-90								
299-W10-13	N	pCi/L	3	3	-0.41	0.72	-0.02	0.64
299-W10-19	N	pCi/L	3	0				
299-W10-20	N	pCi/L	3	1	0.35	0.35	0.35	
299-W10-21	N	pCi/L	2	0				
299-W10-23	N	pCi/L	4	0				
299-W11-14	N	pCi/L	3	1	0.02	0.02	0.02	
299-W11-18	N	pCi/L	2	0				
299-W14-14	Y	pCi/L	6	0				
299-W14-14	N	pCi/L	6	0				
299-W15-15	N	pCi/L	2	2	-0.53	-0.47	-0.50	0.04
299-W15-16	N	pCi/L	2	2	-0.49	-0.35	-0.42	0.10
299-W15-17	N	pCi/L	2	1	0.02	0.02	0.02	
299-W15-41	N	pCi/L	4	0				
299-W15-42	Y	pCi/L	1	0				
299-W15-42	N	pCi/L	3	0				
299-W18-23	N	pCi/L	2	1	-0.28	-0.28	-0.28	
299-W18-27	N	pCi/L	3	2	-0.46	-0.15	-0.30	0.22
299-W6-10	N	pCi/L	2	0				
299-W6-2	N	pCi/L	6	4	-0.59	-0.10	-0.35	0.20
299-W6-7	N	pCi/L	3	2	-0.33	0.02	-0.15	0.24
299-W7-12	N	pCi/L	3	3	-0.72	-0.15	-0.43	0.29
299-W7-4	N	pCi/L	3	3	-0.55	-0.30	-0.44	0.12
299-W7-7	N	pCi/L	3	3	-0.49	-0.44	-0.47	0.02
299-W7-8	N	pCi/L	3	3	-0.62	-0.29	-0.43	0.17
299-W8-1	N	pCi/L	21	6	-0.34	5.40	2.38	2.44
699-43-89	N	pCi/L	1	0				
699-47-60	N	pCi/L	9	1	0.86	0.86	0.86	
699-48-77A	Y	pCi/L	2	0				
699-48-77A	N	pCi/L	52	13	1.10	3.60	2.02	0.83
Iodine-129								
299-W10-1	N	pCi/L	10	2	-0.06	0.17	0.06	0.16
299-W10-13	N	pCi/L	3	2	-0.06	0.42	0.18	0.34
299-W10-19	N	pCi/L	16	2	0.11	0.17	0.14	0.04
299-W10-20	N	pCi/L	12	0				
299-W10-21	N	pCi/L	12	1	0.45	0.45	0.45	
299-W10-22	N	pCi/L	17	0				
299-W10-23	N	pCi/L	11	0				
299-W10-4	N	pCi/L	17	0				
299-W10-5	N	pCi/L	4	0				
299-W11-10	N	pCi/L	8	3	-0.45	0.20	-0.03	0.36

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W11-13	N	pCi/L	3	0				
299-W11-14	N	pCi/L	8	6	2.66	4.25	3.43	0.53
299-W11-18	N	pCi/L	10	2	0.84	1.00	0.92	0.11
299-W11-3	N	pCi/L	7	2	0.44	0.50	0.47	0.04
299-W11-37	Y	pCi/L	2	1	1.94	1.94	1.94	
299-W11-37	N	pCi/L	2	0				
299-W11-6	N	pCi/L	8	1	0.44	0.44	0.44	
299-W11-7	N	pCi/L	11	3	1.06	2.13	1.64	0.54
299-W12-1	N	pCi/L	10	3	0.49	0.59	0.53	0.06
299-W14-14	Y	pCi/L	6	0				
299-W14-14	N	pCi/L	18	0				
299-W14-16	N	pCi/L	9	0				
299-W15-15	N	pCi/L	9	1	0.29	0.29	0.29	
299-W15-16	N	pCi/L	10	1	0.02	0.02	0.02	
299-W15-17	N	pCi/L	4	1	0.33	0.33	0.33	
299-W15-2	N	pCi/L	3	0				
299-W15-30	N	pCi/L	2	0				
299-W15-32	N	pCi/L	4	2	0.01	0.14	0.08	0.09
299-W15-33	N	pCi/L	4	0				
299-W15-34	N	pCi/L	3	0				
299-W15-35	N	pCi/L	3	0				
299-W15-36	N	pCi/L	1	0				
299-W15-40	N	pCi/L	10	0				
299-W15-41	N	pCi/L	9	0				
299-W15-44	N	pCi/L	2	0				
299-W15-7	N	pCi/L	2	2	-0.07	0.02	-0.02	0.06
299-W18-1	N	pCi/L	1	1	-0.33	-0.33	-0.33	
299-W18-23	N	pCi/L	11	1	0.14	0.14	0.14	
299-W6-10	N	pCi/L	14	7	0.15	2.10	1.56	0.66
299-W6-2	N	pCi/L	11	1	-0.05	-0.05	-0.05	
299-W6-7	N	pCi/L	6	1	-0.02	-0.02	-0.02	
299-W7-12	N	pCi/L	4	0				
299-W7-4	N	pCi/L	4	1	0.42	0.42	0.42	
299-W7-7	N	pCi/L	4	1	0.33	0.33	0.33	
299-W7-8	N	pCi/L	2	1	-0.25	-0.25	-0.25	
299-W8-1	N	pCi/L	3	0				
699-39-79	N	pCi/L	6	1	0.08	0.08	0.08	
699-43-89	N	pCi/L	1	0				
699-44-64	N	pCi/L	8	3	-0.13	0.11	-0.03	0.13
699-45-69A	N	pCi/L	7	2	0.31	0.32	0.31	0.01
699-47-60	N	pCi/L	5	1	-0.01	-0.01	-0.01	
699-48-71	N	pCi/L	7	2	-0.26	0.18	-0.04	0.31
699-48-77A	Y	pCi/L	2	0				
699-48-77A	N	pCi/L	12	2	0.19	0.37	0.28	0.13
699-55-60A	N	pCi/L	4	1	1.96	1.96	1.96	

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
Technetium-99								
299-W10-1	N	pCi/L	18	18	37.17	433.00	100.56	88.13
299-W10-13	N	pCi/L	5	4	5.94	8.58	7.40	1.23
299-W10-19	N	pCi/L	27	25	14.20	82.18	53.56	22.81
299-W10-20	N	pCi/L	24	23	28.40	69.23	53.37	12.48
299-W10-21	N	pCi/L	24	24	52.70	91.10	69.02	11.02
299-W10-22	N	pCi/L	27	18	18.20	180.00	114.56	48.62
299-W10-23	N	pCi/L	20	20	180.00	470.00	291.35	94.56
299-W10-4	N	pCi/L	24	24	224.00	587.00	387.04	104.31
299-W10-5	N	pCi/L	6	6	22.60	60.00	35.78	13.47
299-W11-10	N	pCi/L	4	4	15.90	28.60	21.13	6.06
299-W11-13	N	pCi/L	3	3	173.00	311.00	229.33	72.40
299-W11-14	N	pCi/L	9	9	32.00	392.00	159.57	138.84
299-W11-18	N	pCi/L	3	3	143.00	702.00	470.00	291.36
299-W11-3	N	pCi/L	3	1	3.69	3.69	3.69	
299-W11-37	Y	pCi/L	2	2	110.00	188.00	149.00	55.15
299-W11-37	N	pCi/L	1	1	142.00	142.00	142.00	
299-W11-6	N	pCi/L	3	3	15.40	26.70	20.33	5.78
299-W11-7	N	pCi/L	11	11	242.00	428.00	379.27	54.39
299-W12-1	N	pCi/L	7	7	224.00	475.00	347.43	99.05
299-W14-14	Y	pCi/L	6	6	29.70	554.00	126.47	210.29
299-W14-14	N	pCi/L	25	25	29.00	556.00	272.02	145.40
299-W14-16	N	pCi/L	11	11	191.00	286.00	238.73	30.10
299-W15-11	N	pCi/L	1	1	31.20	31.20	31.20	
299-W15-15	N	pCi/L	11	11	16.80	124.00	76.67	40.44
299-W15-16	N	pCi/L	12	7	3.38	17.90	10.27	5.36
299-W15-17	N	pCi/L	5	3	6.21	13.90	9.41	4.01
299-W15-2	N	pCi/L	4	0				
299-W15-30	N	pCi/L	2	0				
299-W15-32	N	pCi/L	8	8	121.00	224.00	163.00	29.18
299-W15-33	N	pCi/L	9	9	28.30	47.30	36.19	7.50
299-W15-34	N	pCi/L	12	12	34.20	72.80	48.72	10.37
299-W15-35	N	pCi/L	20	20	196.00	390.00	310.70	57.14
299-W15-36	N	pCi/L	8	8	18.10	51.90	36.56	12.50
299-W15-40	N	pCi/L	18	18	54.10	185.00	101.10	32.39
299-W15-41	N	pCi/L	15	15	308.00	1,980.00	1,063.87	418.87
299-W15-42	Y	pCi/L	1	0				
299-W15-42	N	pCi/L	7	5	13.20	27.10	18.20	6.68
299-W15-43	N	pCi/L	8	7	14.30	32.70	22.53	7.07
299-W15-44	N	pCi/L	9	8	16.30	147.00	67.07	40.73
299-W15-7	N	pCi/L	5	5	4.76	38.60	14.06	14.09
299-W18-23	N	pCi/L	12	10	0.03	58.80	36.55	21.44
299-W18-27	N	pCi/L	3	3	0.07	1.32	0.86	0.69
299-W6-10	N	pCi/L	23	23	94.98	438.00	278.50	75.10
299-W6-2	N	pCi/L	25	23	8.50	363.00	41.92	70.52
299-W6-7	N	pCi/L	7	7	72.00	164.00	117.60	32.71
299-W7-12	N	pCi/L	7	5	6.62	32.80	12.90	11.25

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W7-4	N	pCi/L	7	7	15.50	46.90	34.14	12.33
299-W7-7	N	pCi/L	6	6	3.20	17.30	8.91	5.61
299-W7-8	N	pCi/L	5	4	6.47	10.90	8.08	1.95
299-W8-1	N	pCi/L	7	5	4.34	9.74	6.92	2.24
699-39-79	N	pCi/L	6	6	1.15	164.00	104.74	56.49
699-43-89	N	pCi/L	1	1	16.70	16.70	16.70	
699-44-64	N	pCi/L	8	8	49.20	194.00	145.89	42.23
699-45-69A	N	pCi/L	5	3	0.02	0.17	0.11	0.08
699-47-60	N	pCi/L	12	4	0.76	14.10	6.09	6.03
699-48-71	N	pCi/L	3	3	0.18	149.00	55.09	81.71
699-55-60A	N	pCi/L	4	4	26.20	48.70	32.98	10.58
Uranium								
299-W10-13	N	μg/L	10	10	0.31	1.66	0.73	0.36
299-W10-19	N	μg/L	11	11	0.55	1.90	1.40	0.43
299-W10-20	Y	μg/L	2	2	0.00	0.00	0.00	0.00
299-W10-20	N	μg/L	5	5	0.00	1.21	0.70	0.64
299-W10-21	N	μg/L	4	4	1.87	2.14	2.05	0.13
299-W10-22	N	μg/L	2	2	4.16	4.26	4.21	0.07
299-W10-23	N	μg/L	1	1	1.37	1.37	1.37	
299-W11-10	N	μg/L	2	2	1.12	1.16	1.14	0.03
299-W11-14	N	μg/L	11	11	10.50	106.00	60.64	24.72
299-W11-18	N	μg/L	6	6	1.71	2.60	2.01	0.32
299-W11-3	N	μg/L	7	7	1.47	1.74	1.59	0.10
299-W11-37	Y	μg/L	2	2	411.00	433.00	422.00	15.56
299-W11-37	N	μg/L	2	2	367.00	454.00	410.50	61.52
299-W11-6	N	μg/L	1	1	1.59	1.59	1.59	
299-W11-7	N	μg/L	4	4	1.80	2.08	1.94	0.13
299-W12-1	N	μg/L	7	7	1.05	1.57	1.31	0.22
299-W15-15	N	μg/L	10	9	1.30	12.70	6.36	3.94
299-W15-16	N	μg/L	10	10	0.99	4.17	2.17	1.18
299-W15-17	N	μg/L	9	9	0.71	2.55	1.10	0.55
299-W15-7	N	μg/L	3	3	0.86	1.33	1.08	0.24
299-W18-23	N	μg/L	10	10	0.97	4.20	2.57	1.24
299-W18-27	N	μg/L	10	10	0.01	1.56	0.96	0.41
299-W6-10	N	μg/L	7	7	2.81	34.80	7.89	11.88
299-W6-2	N	μg/L	11	11	0.85	2.03	1.66	0.33
299-W6-7	N	μg/L	9	9	1.90	3.72	2.81	0.51
299-W7-12	N	μg/L	13	13	0.26	1.26	0.83	0.24
299-W7-4	N	μg/L	12	12	0.22	2.22	1.60	0.53
299-W7-7	N	μg/L	13	13	0.44	1.12	0.82	0.17
299-W7-8	N	μg/L	10	10	0.54	3.69	1.31	0.87
299-W8-1	Y	μg/L	15	15	0.60	0.91	0.77	0.08
299-W8-1	N	μg/L	28	28	0.54	1.01	0.78	0.12
699-39-79	N	μg/L	3	3	6.76	10.05	8.80	1.78
699-43-89	N	μg/L	1	1	0.73	0.73	0.73	
699-44-64	N	μg/L	8	8	1.45	2.28	1.66	0.26
699-45-69A	N	μg/L	3	3	1.57	1.99	1.84	0.23

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
699-47-60	N	µg/L	12	12	2.05	3.00	2.49	0.30
699-48-71	N	µg/L	3	3	0.69	1.18	0.96	0.25
699-48-77A	Y	µg/L	39	39	0.14	1.50	0.69	0.39
699-48-77A	N	µg/L	45	45	0.14	1.50	0.79	0.42
699-55-60A	N	µg/L	1	1	8.18	8.18	8.18	
Tritium								
299-W10-1	N	pCi/L	24	24	1,210.00	33,900.00	11,715.54	13,725.18
299-W10-13	N	pCi/L	27	11	89.80	82,700.00	7,786.17	24,846.28
299-W10-19	N	pCi/L	34	25	341.00	7,310.00	1,489.09	1,254.89
299-W10-20	N	pCi/L	28	28	328.00	2,496.70	1,471.55	732.70
299-W10-21	N	pCi/L	29	29	657.00	2,050.00	1,308.08	335.34
299-W10-22	N	pCi/L	27	19	322.00	12,000.00	5,882.11	3,427.43
299-W10-23	N	pCi/L	20	20	11,400.00	25,500.00	18,430.00	4,345.85
299-W10-4	N	pCi/L	29	29	7,960.00	48,800.00	22,817.10	13,023.44
299-W10-5	N	pCi/L	9	9	2,100.00	7,510.00	4,692.31	2,283.81
299-W11-10	N	pCi/L	9	4	191.00	404.00	266.39	94.49
299-W11-13	N	pCi/L	3	3	7,390.00	9,010.00	8,400.00	880.97
299-W11-14	N	pCi/L	12	12	6,910.00	21,0000.00	44,370.42	56,669.74
299-W11-18	N	pCi/L	7	7	114.00	41,500.00	27,567.71	14,396.37
299-W11-3	N	pCi/L	6	4	234.00	603.00	428.98	153.17
299-W11-37	Y	pCi/L	2	2	5,340.00	6,130.00	5,735.00	558.61
299-W11-37	N	pCi/L	4	4	830.09	9,030.00	4,241.67	3,906.85
299-W11-6	N	pCi/L	9	9	435.00	1,270.00	775.14	315.98
299-W11-7	N	pCi/L	15	15	12,851.00	21,800.00	18,416.73	1,907.26
299-W12-1	N	pCi/L	13	13	9,020.00	12,300.00	10,174.69	1,078.88
299-W14-14	Y	pCi/L	6	6	893.00	9,010.00	6,557.17	3,064.76
299-W14-14	N	pCi/L	25	25	859.00	8,800.00	3,166.96	2,503.31
299-W14-16	N	pCi/L	11	11	1,760.00	2,260.00	2,010.00	169.71
299-W15-1	N	pCi/L	1	1	3,820.00	3,820.00	3,820.00	
299-W15-11	N	pCi/L	3	3	453.00	9,690.00	4,944.33	4,623.75
299-W15-15	N	pCi/L	25	18	48.90	29,700.00	3,423.97	6,682.68
299-W15-16	N	pCi/L	24	7	239.00	27,800.00	4,563.00	10,271.58
299-W15-17	N	pCi/L	23	3	4.62	282.93	154.18	140.32
299-W15-2	N	pCi/L	6	1	526.00	526.00	526.00	
299-W15-30	N	pCi/L	2	0				
299-W15-32	N	pCi/L	8	3	83.38	214.00	148.06	65.32
299-W15-33	N	pCi/L	4	4	1,080.00	2,160.00	1,432.50	491.21
299-W15-34	N	pCi/L	5	5	3,030.00	4,450.00	3,510.00	558.79
299-W15-35	N	pCi/L	3	3	2,980.00	3,430.00	3,240.00	233.02
299-W15-36	N	pCi/L	1	1	226.00	226.00	226.00	
299-W15-40	N	pCi/L	18	18	4,040.00	5,900.00	4,697.22	602.16
299-W15-41	N	pCi/L	15	15	5,370.00	12,100.00	6,692.67	1,608.24
299-W15-42	Y	pCi/L	1	0				
299-W15-42	N	pCi/L	3	1	464.00	464.00	464.00	
299-W15-43	N	pCi/L	8	8	357.00	4,760.00	3,183.63	1,701.35
299-W15-44	N	pCi/L	9	7	4,600.00	8,780.00	5,904.29	1,528.78
299-W15-7	N	pCi/L	8	8	414.00	2,285.40	889.05	618.31

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W18-1	N	pCi/L	8	6	46.40	554.00	220.44	176.57
299-W18-23	N	pCi/L	25	14	160.00	2,720.00	986.43	679.30
299-W18-27	N	pCi/L	17	4	102.00	267.00	177.25	73.03
299-W6-10	N	pCi/L	27	27	35,400.00	107,000.00	69,681.78	20,513.40
299-W6-2	N	pCi/L	29	29	495.00	12,100.00	6,523.12	2,674.20
299-W6-7	N	pCi/L	18	18	10,300.00	46,700.00	35,372.22	11,923.42
299-W7-12	N	pCi/L	32	5	39.70	816.00	290.36	339.43
299-W7-4	N	pCi/L	27	18	304.00	817.00	493.22	133.04
299-W7-7	N	pCi/L	35	16	216.00	1570.00	428.34	330.38
299-W7-8	Y	pCi/L	2	2	314.00	420.00	367.00	74.95
299-W7-8	N	pCi/L	24	16	269.00	778.00	444.64	119.94
299-W8-1	N	pCi/L	44	8	101.00	290.00	173.13	70.15
699-39-79	N	pCi/L	15	12	-111.00	5,020.00	1,696.72	1,704.16
699-43-89	N	pCi/L	5	1	25.58	25.58	25.58	
699-44-64	N	pCi/L	14	14	871.00	1,450.00	1,163.25	160.72
699-45-69A	N	pCi/L	9	3	28.70	348.00	151.53	171.91
699-47-60	N	pCi/L	15	6	-277.00	380.00	32.68	215.84
699-48-71	N	pCi/L	23	9	-189.00	252.00	30.79	151.48
699-48-77A	Y	pCi/L	2	2	323.00	343.00	333.00	14.14
699-48-77A	N	pCi/L	64	49	64.30	200,0000.00	28,6662.25	453,210.39
699-55-60A	N	pCi/L	6	6	6,490.00	75,100.00	30,873.17	25,564.02
Nitrate								
299-W10-1	N	µg/L	21	21	55,800.00	1,100,000.00	352,657.14	405,897.36
299-W10-13	N	µg/L	27	27	15,600.00	72,200.00	37,404.61	15,840.70
299-W10-19	N	µg/L	35	35	48,700.00	150,000.00	107,585.71	34,106.32
299-W10-20	N	µg/L	28	28	77,000.00	154,000.00	124,300.00	23,124.83
299-W10-21	N	µg/L	29	29	28,000.00	202,000.00	147,827.59	31,815.39
299-W10-22	N	µg/L	27	27	530.00	176,000.00	70,961.48	62,775.72
299-W10-23	N	µg/L	20	20	271,000.00	584,000.00	375,700.00	86,189.57
299-W10-4	N	µg/L	28	28	150,000.00	2,160,000.00	883,571.43	556,962.76
299-W10-5	N	µg/L	8	8	67,300.00	110,000.00	91,250.00	16,170.25
299-W11-10	N	µg/L	10	10	48,000.00	69,900.00	58,760.00	8,674.64
299-W11-13	N	µg/L	3	3	77,000.00	80,600.00	78,800.00	1,800.00
299-W11-14	N	µg/L	8	8	63,700.00	310,000.00	143,587.50	71,757.26
299-W11-18	N	µg/L	14	14	73,000.00	159,000.00	101,171.43	26,185.95
299-W11-3	N	µg/L	4	4	77,000.00	96,000.00	84,200.00	8,231.65
299-W11-37	Y	µg/L	2	2	133,000.00	159,000.00	146,000.00	18,384.78
299-W11-37	N	µg/L	4	4	34,000.00	150,000.00	91,500.00	58,472.22
299-W11-6	N	µg/L	6	6	38,500.00	70,000.00	48,200.00	12,057.36
299-W11-7	N	µg/L	14	14	142,000.00	207,000.00	172,928.57	18,290.24
299-W12-1	N	µg/L	15	15	223,000.00	341,000.00	287,000.00	37,236.69
299-W14-14	N	µg/L	25	25	32,500.00	251,000.00	106,736.00	56,286.65
299-W14-16	N	µg/L	11	11	72,200.00	90,300.00	82,781.82	6,578.12
299-W15-1	N	µg/L	1	1	135,000.00	135,000.00	135,000.00	
299-W15-11	N	µg/L	4	4	29,000.00	91,600.00	70,775.00	28,302.46
299-W15-15	N	µg/L	25	25	40,800.00	110,000.00	76,448.00	20,049.28
299-W15-16	N	µg/L	24	24	43,800.00	91,000.00	67,839.51	15,454.24

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-17	N	µg/L	22	22	14,600.00	22,600.00	18,109.09	2,717.13
299-W15-2	N	µg/L	7	7	5,750.00	19,000.00	11,008.57	4,985.31
299-W15-31A	N	µg/L	1	1	57,500.00	57,500.00	57,500.00	
299-W15-32	N	µg/L	24	24	6,100.00	500,000.00	319,670.83	132,680.82
299-W15-33	N	µg/L	18	18	68,600.00	120,000.00	93,833.33	15,788.38
299-W15-34	N	µg/L	23	23	57,500.00	105,000.00	88,547.83	14,572.79
299-W15-35	N	µg/L	19	19	85,000.00	134,000.00	113,031.58	15,725.78
299-W15-36	N	µg/L	20	20	33,900.00	84,600.00	67,170.00	16,013.52
299-W15-38	N	µg/L	1	1	189,000.00	189,000.00	189,000.00	
299-W15-39	N	µg/L	1	1	23,500.00	23,500.00	23,500.00	
299-W15-40	N	µg/L	18	18	78,800.00	150,000.00	112,027.78	20,744.07
299-W15-41	N	µg/L	15	15	51,800.00	76,100.00	63,320.00	7,371.59
299-W15-42	Y	µg/L	2	2	93,100.00	95,176.20	94,138.10	1,468.10
299-W15-42	N	µg/L	9	9	117,000.00	178,000.00	151,808.06	23,400.28
299-W15-43	N	µg/L	7	7	55,800.00	201,000.00	99,428.57	49,407.68
299-W15-44	N	µg/L	9	9	74,400.00	185,000.00	124,077.78	36,974.58
299-W15-7	N	µg/L	9	9	12,000.00	182,000.00	35,133.33	55,203.35
299-W18-1	N	µg/L	12	12	95,600.00	330,000.00	186,475.00	86,717.65
299-W18-23	N	µg/L	24	24	5,300.00	60,200.00	25,775.00	21,937.82
299-W18-27	N	µg/L	18	18	3,400.00	4,600.00	3,785.56	334.12
299-W6-10	N	µg/L	27	27	108,000.00	190,000.00	132,592.59	25,297.10
299-W6-2	N	µg/L	33	33	700.00	130,000.00	51,603.03	17,523.69
299-W6-7	N	µg/L	14	14	139,000.00	230,000.00	187,214.29	31,747.03
299-W7-12	N	µg/L	29	29	20,000.00	42,000.00	316,48.28	7,036.77
299-W7-4	N	µg/L	27	27	67,300.00	106,000.00	92,766.67	9,191.51
299-W7-7	N	µg/L	29	29	13,000.00	39,800.00	22,417.24	9,506.69
299-W7-8	Y	µg/L	1	1	12,300.00	12,300.00	12,300.00	
299-W7-8	N	µg/L	23	23	6,200.00	36,000.00	21,352.61	10,422.86
299-W8-1	N	µg/L	44	44	26,000.00	41,800.00	32,930.45	4,238.01
699-39-79	N	µg/L	9	9	5,900.00	116,000.00	20,944.44	35,776.81
699-43-89	N	µg/L	5	5	22,000.00	31,900.00	25,880.00	4,405.34
699-44-64	N	µg/L	13	13	81,000.00	96,000.00	9,0776.92	4,676.74
699-45-69A	N	µg/L	10	10	8,410.00	33,000.00	20,585.00	9,254.57
699-47-60	N	µg/L	19	19	17,972.81	35,900.00	28,129.65	4,526.70
699-48-71	N	µg/L	18	18	24,000.00	135,000.00	50,013.89	29,870.60
699-48-77A	Y	µg/L	4	4	13,811.62	18,100.00	16,221.42	2,212.14
699-48-77A	N	µg/L	58	58	168.00	38,645.96	8,273.16	10,473.26
699-55-60A	N	µg/L	8	8	26,100.00	31,400.00	28,837.50	1,688.56
				Antimony				
299-W10-1	Y		1	0				
299-W10-1	Y	µg/L	18	2	4.80	51.60	28.20	33.09
299-W10-1	N	µg/L	1	0				
299-W10-13	Y	µg/L	27	1	42.50	42.50	42.50	
299-W10-13	N	µg/L	10	0				
299-W10-19	Y	µg/L	26	2	24.00	42.50	33.25	13.08
299-W10-19	N	µg/L	8	0				
299-W10-20	Y	µg/L	28	0				

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W10-20	N	µg/L	8	0				
299-W10-21	Y	µg/L	21	2	3.90	42.50	23.20	27.29
299-W10-21	N	µg/L	4	0				
299-W10-22	Y	µg/L	24	0				
299-W10-23	Y	µg/L	20	2	2.80	3.20	3.00	0.28
299-W10-4	Y	µg/L	27	5	3.30	45.70	12.22	18.72
299-W10-4	N	µg/L	3	0				
299-W10-5	Y	µg/L	6	0				
299-W10-5	N	µg/L	1	0				
299-W11-10	Y		2	0				
299-W11-10	Y	µg/L	1	0				
299-W11-10	N	µg/L	1	0				
299-W11-13	Y	µg/L	3	0				
299-W11-18	Y		3	0				
299-W11-18	Y	µg/L	2	0				
299-W11-18	N	µg/L	1	0				
299-W11-3	Y		2	0				
299-W11-3	Y	µg/L	1	0				
299-W11-3	N	µg/L	1	1	46.00	46.00	46.00	
299-W11-37	Y	µg/L	3	0				
299-W11-6	Y		2	0				
299-W11-6	Y	µg/L	1	0				
299-W11-6	N	µg/L	1	0				
299-W11-7	Y		2	0				
299-W11-7	Y	µg/L	11	1	3.40	3.40	3.40	
299-W12-1	Y		1	0				
299-W12-1	Y	µg/L	7	0				
299-W12-1	N	µg/L	1	0				
299-W14-14	Y	µg/L	25	1	3.80	3.80	3.80	
299-W14-16	Y	µg/L	11	0				
299-W15-11	Y		1	0				
299-W15-15	Y	µg/L	24	1	56.50	56.50	56.50	
299-W15-15	N	µg/L	6	0				
299-W15-16	Y	µg/L	23	0				
299-W15-16	N	µg/L	6	0				
299-W15-17	Y	µg/L	22	0				
299-W15-17	N	µg/L	6	0				
299-W15-2	Y	µg/L	4	0				
299-W15-2	N	µg/L	1	0				
299-W15-32	Y	µg/L	7	1	24.00	24.00	24.00	
299-W15-35	Y	µg/L	1	0				
299-W15-37	Y	µg/L	1	0				
299-W15-38	Y	µg/L	1	0				
299-W15-40	Y	µg/L	18	0				
299-W15-41	Y	µg/L	15	0				
299-W15-42	Y	µg/L	4	0				
299-W15-43	Y	µg/L	8	1	34.60	34.60	34.60	

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-44	Y	µg/L	9	0				
299-W15-7	Y	µg/L	1	0				
299-W15-7	N	µg/L	3	0				
299-W18-1	Y	µg/L	5	1	2.90	2.90	2.90	
299-W18-21	Y	µg/L	24	1	28.80	28.80	28.80	
299-W18-21	N	µg/L	6	0				
299-W18-22	Y	µg/L	23	1	34.00	34.00	34.00	
299-W18-22	N	µg/L	6	0				
299-W18-23	Y	µg/L	24	3	26.00	77.00	44.03	28.59
299-W18-23	N	µg/L	6	0				
299-W6-10	Y	µg/L	24	0				
299-W6-10	N	µg/L	6	0				
299-W6-2	Y	µg/L	25	1	42.50	42.50	42.50	
299-W6-2	N	µg/L	12	0				
299-W6-7	Y	µg/L	11	0				
299-W6-7	N	µg/L	9	0				
299-W7-11	Y	µg/L	26	0				
299-W7-11	N	µg/L	11	0				
299-W7-4	Y	µg/L	27	2	4.10	42.50	23.30	27.15
299-W7-4	N	µg/L	10	0				
299-W7-7	Y	µg/L	32	2	37.00	42.50	39.75	3.89
299-W7-7	N	µg/L	14	2	30.60	32.00	31.30	0.99
299-W7-8	Y	µg/L	24	1	42.50	42.50	42.50	
299-W7-8	N	µg/L	10	1	35.00	35.00	35.00	
299-W8-1	Y	µg/L	42	1	30.00	30.00	30.00	
299-W8-1	N	µg/L	25	0				
699-39-79	Y	µg/L	2	0				
699-39-79	N	µg/L	1	0				
699-43-89	Y	µg/L	1	0				
699-44-64	Y	µg/L	1	0				
699-44-64	N	µg/L	1	0				
699-45-69A	Y	µg/L	3	0				
699-47-60	Y	µg/L	9	0				
699-47-60	N	µg/L	8	0				
699-48-71	Y	µg/L	3	0				
699-48-71	N	µg/L	2	0				
699-48-77A	Y	µg/L	51	1	28.80	28.80	28.80	
699-48-77A	N	µg/L	53	0				
699-55-60A	Y		1	0				
699-55-60A	Y	µg/L	2	0				
699-55-60A	N		1	0				
699-55-60A	N	µg/L	1	0				
Iron								
299-W10-1	Y	µg/L	19	11	15.00	255.00	70.08	73.56
299-W10-1	N	µg/L	1	1	752.00	752.00	752.00	
299-W10-13	Y	µg/L	27	23	7.90	110.00	38.30	25.08
299-W10-13	N	µg/L	10	10	120.00	1,400.00	623.00	416.07

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W10-19	Y	µg/L	26	18	12.70	180.00	62.40	42.55
299-W10-19	N	µg/L	8	8	80.00	2,100.00	535.88	716.55
299-W10-20	Y	µg/L	28	24	12.00	630.00	77.20	138.78
299-W10-20	N	µg/L	8	8	22.00	15,000.00	3,352.13	5,567.76
299-W10-21	Y	µg/L	21	17	12.00	97.00	39.62	19.57
299-W10-21	N	µg/L	4	4	92.00	1,700.00	873.00	844.58
299-W10-22	Y	µg/L	24	19	12.40	83.10	41.93	18.82
299-W10-23	Y	µg/L	20	8	21.30	78.80	44.39	17.48
299-W10-4	Y	µg/L	27	18	16.50	74.40	45.54	15.70
299-W10-4	N	µg/L	3	3	168.00	237.00	196.67	35.95
299-W10-5	Y	µg/L	6	3	19.70	464.00	169.10	255.40
299-W10-5	N	µg/L	1	1	4,610.00	4,610.00	4,610.00	
299-W11-10	Y	µg/L	3	3	17.00	28.30	20.77	6.52
299-W11-10	N	µg/L	1	1	17,500.00	17,500.00	17,500.00	
299-W11-13	Y	µg/L	3	2	49.70	52.60	51.15	2.05
299-W11-18	Y		1	0				
299-W11-18	Y	µg/L	4	2	12.00	13.00	12.50	0.71
299-W11-18	N	µg/L	1	1	58.20	58.20	58.20	
299-W11-3	Y		1	0				
299-W11-3	Y	µg/L	2	1	12.00	12.00	12.00	
299-W11-3	N	µg/L	1	1	691.00	691.00	691.00	
299-W11-37	Y	µg/L	3	3	35.70	109.00	67.63	37.55
299-W11-6	Y	µg/L	3	3	15.00	23.30	18.43	4.33
299-W11-6	N	µg/L	1	1	1,330.00	1,330.00	1,330.00	
299-W11-7	Y		1	0				
299-W11-7	Y	µg/L	12	10	28.00	66.70	46.59	13.96
299-W12-1	Y	µg/L	8	6	21.60	47.40	35.02	11.94
299-W12-1	N	µg/L	1	1	42.70	42.70	42.70	
299-W14-14	Y	µg/L	25	18	19.80	139.00	65.36	41.91
299-W14-16	Y	µg/L	11	5	26.80	61.20	40.00	14.70
299-W15-11	Y	µg/L	1	1	30.00	30.00	30.00	
299-W15-15	Y	µg/L	24	23	25.00	143.00	57.82	24.21
299-W15-15	N	µg/L	6	6	89.00	1,500.00	434.83	536.66
299-W15-16	Y	µg/L	23	20	13.30	80.00	41.19	17.58
299-W15-16	N	µg/L	6	6	320.00	670.00	455.00	155.53
299-W15-17	Y	µg/L	22	19	9.40	59.50	42.71	13.13
299-W15-17	N	µg/L	6	6	150.00	1,200.00	761.67	389.12
299-W15-2	Y	µg/L	4	3	35.30	80.50	55.87	22.87
299-W15-2	N	µg/L	1	1	6,690.00	6,690.00	6,690.00	
299-W15-32	Y	µg/L	7	5	18.00	75.30	42.34	23.15
299-W15-35	Y	µg/L	1	1	30.20	30.20	30.20	
299-W15-37	Y	µg/L	1	0				
299-W15-38	Y	µg/L	1	1	40.40	40.40	40.40	
299-W15-40	Y	µg/L	18	12	26.30	2,080.00	210.90	588.78
299-W15-41	Y	µg/L	15	11	21.60	158.00	44.91	38.24
299-W15-42	Y	µg/L	5	2	18.00	33.60	25.80	11.03
299-W15-42	N	µg/L	3	3	148.00	378.00	289.67	123.93

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-43	Y	µg/L	8	6	30.70	550.00	178.85	188.63
299-W15-44	Y	µg/L	9	2	17.60	19.00	18.30	0.99
299-W15-7	Y	µg/L	1	0				
299-W15-7	N	µg/L	3	2	29.60	4,100.00	2,064.80	2,878.21
299-W18-1	Y	µg/L	5	3	30.20	172.00	81.83	78.36
299-W18-21	Y	µg/L	24	20	28.00	540.00	81.63	113.95
299-W18-21	N	µg/L	6	6	420.00	1,500.00	946.67	450.19
299-W18-22	Y	µg/L	24	22	20.00	142.00	44.60	25.06
299-W18-22	N	µg/L	6	6	190.00	660.00	471.67	161.67
299-W18-23	Y	µg/L	24	19	15.00	79.00	35.68	16.66
299-W18-23	N	µg/L	6	6	95.00	1,200.00	394.00	436.14
299-W6-10	Y	µg/L	24	22	19.00	174.00	50.93	33.05
299-W6-10	N	µg/L	6	6	180.00	630.00	346.67	169.67
299-W6-2	Y	µg/L	25	20	6.30	254.00	51.79	57.26
299-W6-2	N	µg/L	12	12	100.00	2,500.00	615.83	658.66
299-W6-7	Y	µg/L	11	7	20.00	120.00	44.71	33.96
299-W6-7	N	µg/L	9	9	490.00	4400.00	1,954.44	1,374.01
299-W7-11	Y	µg/L	26	20	13.00	145.00	55.89	34.79
299-W7-11	N	µg/L	11	11	230.00	2,200.00	841.82	605.11
299-W7-4	Y	µg/L	27	22	15.00	142.00	43.41	26.50
299-W7-4	N	µg/L	10	10	100.00	950.00	402.00	220.44
299-W7-7	Y	µg/L	32	25	17.00	601.00	74.09	113.44
299-W7-7	N	µg/L	14	14	340.00	3,900.00	1,263.21	884.37
299-W7-8	Y	µg/L	24	22	16.00	176.00	90.46	56.25
299-W7-8	N	µg/L	10	10	640.00	1,500.00	1,182.00	271.37
299-W8-1	Y	µg/L	42	37	12.20	190.00	38.59	29.15
299-W8-1	N	µg/L	25	25	69.70	690.00	286.02	188.72
699-39-79	Y	µg/L	2	2	23.00	40.80	31.90	12.59
699-39-79	N	µg/L	1	1	912.00	912.00	912.00	
699-43-89	Y	µg/L	1	1	9.30	9.30	9.30	
699-44-64	Y	µg/L	1	0				
699-44-64	N	µg/L	1	1	124.00	124.00	124.00	
699-45-69A	Y	µg/L	3	3	72.80	145.00	119.60	40.58
699-47-60	Y	µg/L	11	5	11.30	54.70	30.26	18.20
699-47-60	N	µg/L	10	9	32.30	545.00	114.06	164.72
699-48-71	Y	µg/L	3	2	33.00	217.00	125.00	130.11
699-48-71	N	µg/L	2	2	42.00	180.00	111.00	97.58
699-48-77A	Y	µg/L	49	34	5.10	97.10	27.71	20.80
699-48-77A	N	µg/L	51	49	46.80	1,120.00	280.83	235.28
699-55-60A	Y	µg/L	3	2	12.00	52.90	32.45	28.92
699-55-60A	N	µg/L	2	2	68.20	170.00	119.10	71.98
Manganese								
299-W10-1	Y		1	0				
299-W10-1	Y	µg/L	18	14	0.69	5.90	3.73	1.56
299-W10-1	N	µg/L	1	1	16.60	16.60	16.60	
299-W10-13	Y	µg/L	27	16	0.57	4.90	2.27	1.32
299-W10-13	N	µg/L	10	7	9.60	30.00	16.23	7.15

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W10-19	Y	µg/L	26	22	1.00	11.40	5.16	3.78
299-W10-19	N	µg/L	8	8	2.00	50.00	12.74	16.97
299-W10-20	Y	µg/L	28	24	2.50	81.00	10.65	16.49
299-W10-20	N	µg/L	8	7	5.00	250.00	80.37	101.72
299-W10-21	Y	µg/L	21	18	0.74	9.90	3.28	2.30
299-W10-21	N	µg/L	4	4	1.70	30.00	15.30	14.28
299-W10-22	Y	µg/L	24	20	0.68	4.60	2.92	1.00
299-W10-23	Y	µg/L	20	15	1.40	15.00	5.71	4.90
299-W10-4	Y	µg/L	27	26	2.20	24.00	9.40	6.66
299-W10-4	N	µg/L	3	3	4.00	6.60	5.10	1.35
299-W10-5	Y	µg/L	6	6	2.90	9.10	5.38	2.93
299-W10-5	N	µg/L	1	1	379.00	379.00	379.00	
299-W11-10	Y	µg/L	3	3	1.70	4.10	2.63	1.29
299-W11-10	N	µg/L	1	1	412.00	412.00	412.00	
299-W11-13	Y	µg/L	3	3	11.80	16.70	15.03	2.80
299-W11-14	Y		1	0				
299-W11-14	Y	µg/L	2	2	1.70	2.60	2.15	0.64
299-W11-14	N	µg/L	1	1	27.90	27.90	27.90	
299-W11-18	Y		3	0				
299-W11-18	Y	µg/L	2	0				
299-W11-18	N	µg/L	1	1	2.20	2.20	2.20	
299-W11-3	Y		2	0				
299-W11-3	Y	µg/L	1	0				
299-W11-3	N	µg/L	1	1	12.90	12.90	12.90	
299-W11-37	Y	µg/L	3	3	2.30	11.00	5.27	4.97
299-W11-6	Y	µg/L	3	3	1.60	4.60	2.80	1.59
299-W11-6	N	µg/L	1	1	24.50	24.50	24.50	
299-W11-7	Y		1	0				
299-W11-7	Y	µg/L	12	9	0.51	8.30	3.79	2.33
299-W12-1	Y		1	0				
299-W12-1	Y	µg/L	7	5	3.80	5.50	4.32	0.70
299-W12-1	N	µg/L	1	0				
299-W14-14	Y	µg/L	25	19	0.98	65.30	16.00	20.06
299-W14-16	Y	µg/L	11	9	0.28	14.70	4.02	4.31
299-W15-11	Y	µg/L	1	1	2.60	2.60	2.60	
299-W15-15	Y	µg/L	24	20	0.66	5.20	2.93	1.25
299-W15-15	N	µg/L	6	3	4.60	35.00	16.87	16.03
299-W15-16	Y	µg/L	23	18	0.60	4.70	2.58	1.06
299-W15-16	N	µg/L	6	4	7.90	13.00	10.63	2.76
299-W15-17	Y	µg/L	22	18	0.37	5.60	2.96	1.39
299-W15-17	N	µg/L	6	6	5.40	27.00	17.73	8.45
299-W15-2	Y	µg/L	4	4	4.90	83.60	27.02	38.00
299-W15-2	N	µg/L	1	1	156.00	156.00	156.00	
299-W15-32	Y	µg/L	7	6	0.57	7.00	3.73	2.31
299-W15-35	Y	µg/L	1	1	3.40	3.40	3.40	
299-W15-38	Y	µg/L	1	1	4.80	4.80	4.80	
299-W15-40	Y	µg/L	18	14	0.41	47.90	10.15	13.65

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-41	Y	µg/L	15	11	0.73	16.80	4.88	5.09
299-W15-42	Y	µg/L	4	4	3.90	6.30	4.82	1.03
299-W15-43	Y	µg/L	8	8	2.50	297.00	55.24	99.45
299-W15-44	Y	µg/L	9	9	4.10	1320.00	251.43	417.55
299-W15-7	Y	µg/L	1	0				
299-W15-7	N	µg/L	3	1	570.00	570.00	570.00	
299-W18-1	Y	µg/L	5	3	0.37	4.20	2.06	1.96
299-W18-23	Y	µg/L	24	19	0.46	5.80	2.89	1.54
299-W18-23	N	µg/L	6	5	3.60	23.00	9.86	7.72
299-W18-27	Y	µg/L	18	16	1.40	16.70	5.71	5.21
299-W18-27	N	µg/L	9	9	27.00	90.00	58.78	23.44
299-W6-10	Y	µg/L	24	18	1.00	10.50	4.12	2.57
299-W6-10	N	µg/L	6	5	4.50	13.00	9.66	3.15
299-W6-2	Y	µg/L	25	12	0.77	4.80	2.43	1.30
299-W6-2	N	µg/L	12	7	3.60	37.00	13.84	11.90
299-W6-7	Y	µg/L	11	5	1.60	39.00	10.20	16.13
299-W6-7	N	µg/L	9	8	10.00	210.00	56.88	64.44
299-W7-12	Y	µg/L	29	20	1.20	11.00	3.67	2.28
299-W7-12	N	µg/L	10	10	20.00	270.00	90.30	76.07
299-W7-4	Y	µg/L	27	15	0.97	5.50	2.88	1.11
299-W7-4	N	µg/L	10	5	8.20	20.00	10.96	5.07
299-W7-7	Y	µg/L	32	21	1.50	21.80	6.03	5.84
299-W7-7	N	µg/L	14	14	10.00	87.00	29.58	19.77
299-W7-8	Y	µg/L	24	16	1.70	26.40	8.77	7.61
299-W7-8	N	µg/L	10	10	20.00	35.00	27.20	5.87
299-W8-1	Y	µg/L	42	18	0.78	9.43	2.64	1.89
299-W8-1	N	µg/L	25	9	2.60	15.00	9.33	4.23
699-39-79	Y	µg/L	2	2	3.30	4.30	3.80	0.71
699-39-79	N	µg/L	1	1	24.10	24.10	24.10	
699-43-89	Y	µg/L	1	1	3.00	3.00	3.00	
699-44-64	Y	µg/L	1	0				
699-44-64	N	µg/L	1	1	3.40	3.40	3.40	
699-45-69A	Y	µg/L	3	3	1.60	2.20	1.93	0.31
699-47-60	Y	µg/L	11	4	1.10	5.00	3.50	1.69
699-47-60	N	µg/L	10	5	1.60	6.60	3.88	2.22
699-48-71	Y	µg/L	3	2	0.68	1.60	1.14	0.65
699-48-71	N	µg/L	2	0				
699-48-77A	Y	µg/L	49	7	2.40	18.90	6.11	5.76
699-48-77A	N	µg/L	51	17	3.50	27.00	10.03	6.14
699-55-60A	Y		1	0				
699-55-60A	Y	µg/L	2	1	6.80	6.80	6.80	
699-55-60A	N	µg/L	2	1	2.10	2.10	2.10	
				1,2-Dichloroethane				
299-W10-1	N	µg/L	13	0				
299-W10-13	N	µg/L	27	3	0.14	1.00	0.51	0.44
299-W10-19	N	µg/L	27	4	0.14	50.00	14.68	23.82
299-W10-20	N	µg/L	31	6	3.50	100.00	60.58	44.70

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W10-21	N	µg/L	32	6	0.14	50.00	27.52	24.82
299-W10-22	N	µg/L	4	0				
299-W10-23	N	µg/L	5	0				
299-W10-4	N	µg/L	13	1	0.14	0.14	0.14	
299-W10-5	N	µg/L	8	2	8.50	8.50	8.50	0.00
299-W11-10	N	µg/L	11	0				
299-W11-13	N	µg/L	3	0				
299-W11-18	N		1	0				
299-W11-18	N	µg/L	12	3	8.50	10.00	9.00	0.87
299-W11-3	N	µg/L	10	1	8.50	8.50	8.50	
299-W11-37	Y	µg/L	2	1	3.40	3.40	3.40	
299-W11-37	N	µg/L	2	0				
299-W11-6	N	µg/L	11	2	0.27	8.50	4.38	5.82
299-W11-7	N	µg/L	10	1	10.00	10.00	10.00	
299-W12-1	N		1	0				
299-W12-1	N	µg/L	15	0				
299-W14-14	N	µg/L	12	0				
299-W15-1	N	µg/L	3	0				
299-W15-11	N		1	0				
299-W15-11	N	µg/L	5	1	100.00	100.00	100.00	
299-W15-15	N	µg/L	33	5	0.45	20.00	11.69	8.38
299-W15-16	N	µg/L	28	3	0.45	50.00	17.15	28.45
299-W15-17	N	µg/L	24	0				
299-W15-2	N	µg/L	7	0				
299-W15-30	N	µg/L	1	0				
299-W15-31A	N	µg/L	8	0				
299-W15-32	N	µg/L	8	0				
299-W15-33	N	µg/L	2	0				
299-W15-34	N	µg/L	5	0				
299-W15-35	N	µg/L	2	1	0.76	0.76	0.76	
299-W15-36	N	µg/L	4	0				
299-W15-37	N	µg/L	6	1	3.40	3.40	3.40	
299-W15-38	N	µg/L	4	0				
299-W15-39	N	µg/L	3	0				
299-W15-40	N	µg/L	5	0				
299-W15-41	N	µg/L	5	1	8.50	8.50	8.50	
299-W15-42	Y	µg/L	4	0				
299-W15-42	N	µg/L	8	0				
299-W15-43	N	µg/L	8	0				
299-W15-7	N	µg/L	13	0				
299-W18-1	Y	µg/L	1	0				
299-W18-1	N	µg/L	14	1	8.50	8.50	8.50	
299-W18-21	N	µg/L	28	3	0.45	40.00	16.82	20.64
299-W18-22	N	µg/L	25	2	0.27	0.27	0.27	0.00
299-W18-23	N	µg/L	26	4	0.45	40.00	13.86	17.86
299-W6-10	N	µg/L	15	2	0.14	0.45	0.29	0.22
299-W6-2	N	µg/L	25	4	0.14	20.00	6.07	9.46

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W6-7	N	µg/L	14	1	0.45	0.45	0.45	
299-W7-11	N	µg/L	26	0				
299-W7-4	N	µg/L	27	3	3.50	20.00	12.83	8.46
299-W7-7	N	µg/L	29	1	0.14	0.14	0.14	
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	23	0				
299-W8-1	N	µg/L	44	0				
699-39-79	N		5	0				
699-39-79	N	µg/L	8	0				
699-43-89	N	µg/L	5	1	0.13	0.13	0.13	
699-44-64	N	µg/L	6	0				
699-45-69A	N		1	0				
699-45-69A	N	µg/L	8	0				
699-47-60	N	µg/L	8	0				
699-48-71	N		1	0				
699-48-71	N	µg/L	12	0				
699-48-77A	Y	µg/L	2	0				
699-48-77A	N		1	0				
699-48-77A	N	µg/L	55	2	5.00	5.00	5.00	0.00
699-55-60A	N	µg/L	3	0				
				Benzene				
299-W10-1	N	µg/L	13	1	0.21	0.21	0.21	
299-W10-13	N	µg/L	27	1	0.40	0.40	0.40	
299-W10-19	N	µg/L	27	4	0.17	50.00	14.39	23.93
299-W10-20	N	µg/L	31	7	0.11	100.00	51.62	47.01
299-W10-21	N	µg/L	32	5	4.20	50.00	32.84	23.59
299-W10-22	N	µg/L	4	0				
299-W10-23	N	µg/L	5	0				
299-W10-4	N	µg/L	13	1	0.11	0.11	0.11	
299-W10-5	N	µg/L	8	2	12.00	12.00	12.00	0.00
299-W11-10	N	µg/L	11	1	0.21	0.21	0.21	
299-W11-13	N	µg/L	3	0				
299-W11-18	N		1	0				
299-W11-18	N	µg/L	12	5	0.23	12.00	6.59	5.98
299-W11-3	N	µg/L	10	1	12.00	12.00	12.00	
299-W11-37	Y	µg/L	2	1	4.60	4.60	4.60	
299-W11-37	N	µg/L	2	0				
299-W11-6	N	µg/L	11	1	12.00	12.00	12.00	
299-W11-7	N	µg/L	10	2	0.26	8.00	4.13	5.47
299-W12-1	N		1	0				
299-W12-1	N	µg/L	15	0				
299-W14-14	N	µg/L	12	0				
299-W15-1	N	µg/L	3	0				
299-W15-11	N		1	0				
299-W15-11	N	µg/L	5	0				
299-W15-15	N	µg/L	33	5	0.65	20.00	11.19	8.56
299-W15-16	N	µg/L	28	4	0.06	50.00	12.89	24.74

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-17	N	µg/L	24	1	0.12	0.12	0.12	
299-W15-2	N	µg/L	7	0				
299-W15-30	N	µg/L	1	0				
299-W15-31A	N	µg/L	8	0				
299-W15-32	N	µg/L	8	0				
299-W15-33	N	µg/L	2	0				
299-W15-34	N	µg/L	5	0				
299-W15-35	N	µg/L	2	0				
299-W15-36	N	µg/L	4	0				
299-W15-37	N	µg/L	6	1	4.60	4.60	4.60	
299-W15-38	N	µg/L	4	0				
299-W15-39	N	µg/L	3	0				
299-W15-40	N	µg/L	5	0				
299-W15-41	N	µg/L	5	1	12.00	12.00	12.00	
299-W15-42	Y	µg/L	4	0				
299-W15-42	N	µg/L	8	0				
299-W15-43	N	µg/L	8	0				
299-W15-7	N	µg/L	13	0				
299-W18-1	Y	µg/L	1	0				
299-W18-1	N	µg/L	14	1	12.00	12.00	12.00	
299-W18-21	N	µg/L	28	3	0.65	40.00	16.38	20.83
299-W18-22	N	µg/L	25	0				
299-W18-23	N	µg/L	26	5	0.65	10.00	5.43	3.85
299-W6-10	N	µg/L	15	1	0.65	0.65	0.65	
299-W6-2	N	µg/L	25	1	4.00	4.00	4.00	
299-W6-7	N	µg/L	14	2	0.23	0.65	0.44	0.30
299-W7-11	N	µg/L	26	0				
299-W7-4	N	µg/L	27	2	4.20	15.00	9.60	7.64
299-W7-7	N	µg/L	29	3	0.35	1.30	0.95	0.52
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	23	1	0.32	0.32	0.32	
299-W8-1	N	µg/L	44	2	0.15	1.00	0.57	0.60
699-39-79	N		5	0				
699-39-79	N	µg/L	8	1	7.00	7.00	7.00	
699-43-89	N	µg/L	5	0				
699-44-64	N	µg/L	6	0				
699-45-69A	N		1	0				
699-45-69A	N	µg/L	8	0				
699-47-60	N	µg/L	8	0				
699-48-71	N		1	0				
699-48-71	N	µg/L	12	0				
699-48-77A	Y	µg/L	2	0				
699-48-77A	N		1	0				
699-48-77A	N	µg/L	59	4	1.00	5.00	4.00	2.00
699-55-60A	N	µg/L	3	0				

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
Tetrachloroethylene								
299-W10-1	N	µg/L	13	2	0.33	0.49	0.41	0.11
299-W10-13	N	µg/L	27	3	0.06	1.00	0.49	0.48
299-W10-19	N	µg/L	27	12	0.22	50.00	5.30	14.21
299-W10-20	N	µg/L	31	23	0.41	100.00	16.27	34.29
299-W10-21	N	µg/L	31	13	0.13	50.00	12.52	21.53
299-W10-22	N	µg/L	4	2	0.36	0.40	0.38	0.03
299-W10-23	N	µg/L	5	3	0.58	0.81	0.68	0.12
299-W10-4	N	µg/L	13	5	0.47	0.84	0.61	0.14
299-W10-5	N	µg/L	8	6	0.20	28.00	9.78	14.12
299-W11-10	N	µg/L	11	3	0.14	0.30	0.22	0.08
299-W11-13	N	µg/L	3	0				
299-W11-18	N	µg/L	13	8	0.16	28.00	8.31	12.52
299-W11-3	N	µg/L	10	2	0.16	28.00	14.08	19.69
299-W11-37	Y	µg/L	2	1	11.00	11.00	11.00	
299-W11-37	N	µg/L	2	0				
299-W11-6	N	µg/L	11	3	0.18	28.00	9.47	16.04
299-W11-7	N	µg/L	10	6	0.30	9.00	1.80	3.53
299-W12-1	N		1	0				
299-W12-1	N	µg/L	15	0				
299-W14-14	N	µg/L	12	3	0.40	0.50	0.43	0.06
299-W15-1	N	µg/L	3	2	0.90	1.00	0.95	0.07
299-W15-11	N	µg/L	6	2	0.64	0.93	0.79	0.21
299-W15-15	N	µg/L	33	10	0.11	20.00	5.82	8.14
299-W15-16	N	µg/L	28	19	0.41	50.00	3.45	11.28
299-W15-17	N	µg/L	24	1	0.05	0.05	0.05	
299-W15-2	N	µg/L	7	0				
299-W15-30	N	µg/L	1	1	2.00	2.00	2.00	
299-W15-31A	N	µg/L	8	2	0.78	1.00	0.89	0.16
299-W15-32	N	µg/L	24	11	0.65	2.00	1.29	0.57
299-W15-33	N	µg/L	19	5	0.44	1.22	0.93	0.29
299-W15-34	N	µg/L	25	13	1.00	2.00	1.12	0.28
299-W15-35	N	µg/L	20	5	0.89	2.00	1.17	0.47
299-W15-36	N	µg/L	19	4	0.39	2.00	0.87	0.76
299-W15-37	N	µg/L	12	2	0.42	11.00	5.71	7.48
299-W15-38	N	µg/L	4	1	1.00	1.00	1.00	
299-W15-39	N	µg/L	3	1	0.38	0.38	0.38	
299-W15-40	N	µg/L	5	5	1.00	1.40	1.26	0.17
299-W15-41	N	µg/L	5	3	0.52	28.00	9.71	15.84
299-W15-42	Y	µg/L	4	0				
299-W15-42	N	µg/L	10	3	0.87	0.98	0.92	0.06
299-W15-43	N	µg/L	8	5	0.78	1.20	1.04	0.18
299-W15-7	N	µg/L	13	7	0.84	2.00	1.26	0.37
299-W18-1	Y	µg/L	1	0				
299-W18-1	N	µg/L	15	6	1.10	28.00	5.95	10.81
299-W18-21	N	µg/L	28	7	0.19	40.00	7.50	14.66
299-W18-22	N	µg/L	25	0				

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W18-23	N	µg/L	26	6	0.08	40.00	9.22	15.47
299-W6-10	N	µg/L	15	7	0.28	1.10	0.66	0.37
299-W6-2	N	µg/L	25	5	0.08	20.00	4.90	8.60
299-W6-7	N	µg/L	14	3	0.08	1.10	0.57	0.51
299-W7-11	N	µg/L	26	0				
299-W7-4	N	µg/L	27	13	0.18	20.00	3.30	6.49
299-W7-7	N	µg/L	29	1	0.06	0.06	0.06	
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	23	0				
299-W8-1	N	µg/L	44	0				
699-39-79	N		3	0				
699-39-79	N	µg/L	10	2	0.10	0.20	0.15	0.07
699-43-89	N	µg/L	5	1	0.32	0.32	0.32	
699-44-64	N	µg/L	6	0				
699-45-69A	N		1	0				
699-45-69A	N	µg/L	8	2	0.07	0.10	0.09	0.02
699-47-60	N	µg/L	8	0				
699-48-71	N		1	0				
699-48-71	N	µg/L	12	0				
699-48-77A	Y	µg/L	2	0				
699-48-77A	N		1	0				
699-48-77A	N	µg/L	55	4	5.00	37.00	17.00	15.32
699-55-60A	N	µg/L	3	0				
Methylene Chloride								
299-W10-1	N	µg/L	13	3	0.80	54.00	18.59	30.67
299-W10-13	N	µg/L	27	8	0.06	2.40	0.67	0.76
299-W10-19	N	µg/L	27	10	0.06	58.00	16.80	21.54
299-W10-20	N	µg/L	31	14	0.13	220.00	44.73	66.12
299-W10-21	N	µg/L	32	10	0.06	50.00	19.37	22.60
299-W10-22	N	µg/L	4	2	0.30	0.57	0.43	0.19
299-W10-23	N	µg/L	5	1	1.10	1.10	1.10	
299-W10-4	N	µg/L	13	6	0.06	4.00	1.62	1.64
299-W10-5	N	µg/L	8	5	0.08	86.00	33.46	45.27
299-W11-10	N	µg/L	11	2	0.52	52.00	26.26	36.40
299-W11-13	N	µg/L	3	2	0.95	1.10	1.02	0.11
299-W11-14	N		1	0				
299-W11-14	N	µg/L	11	5	0.50	40.00	10.56	17.07
299-W11-18	N		1	0				
299-W11-18	N	µg/L	12	4	0.06	55.00	37.02	25.36
299-W11-3	N	µg/L	10	4	0.63	73.00	18.83	36.11
299-W11-37	Y	µg/L	2	1	25.00	25.00	25.00	
299-W11-37	N	µg/L	2	1	0.94	0.94	0.94	
299-W11-6	N	µg/L	11	4	0.18	56.00	14.31	27.80
299-W11-7	N	µg/L	10	5	0.31	38.00	8.62	16.46
299-W12-1	N		1	0				
299-W12-1	N	µg/L	15	6	0.11	11.00	3.07	4.04
299-W14-14	N	µg/L	12	5	0.30	0.51	0.38	0.09

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W15-1	N	µg/L	3	3	0.60	24.00	8.87	13.12
299-W15-11	N		1	0				
299-W15-11	N	µg/L	5	1	2.00	2.00	2.00	
299-W15-15	N	µg/L	33	9	0.15	92.00	26.76	31.34
299-W15-16	N	µg/L	28	10	0.20	180.00	36.82	59.62
299-W15-17	N	µg/L	24	5	0.30	1.00	0.51	0.29
299-W15-2	N	µg/L	7	2	0.16	0.50	0.33	0.24
299-W15-30	N	µg/L	1	1	14.00	14.00	14.00	
299-W15-31A	N	µg/L	8	3	0.30	310.00	104.77	177.75
299-W15-32	N	µg/L	24	13	0.29	400.00	110.00	142.64
299-W15-33	N	µg/L	19	13	2.00	740.52	131.66	209.44
299-W15-34	N	µg/L	25	13	0.29	353.35	68.65	114.25
299-W15-35	N	µg/L	20	13	1.00	347.64	83.95	121.47
299-W15-36	N	µg/L	19	10	1.00	320.00	57.68	100.58
299-W15-38	N	µg/L	4	2	10.00	230.00	120.00	155.56
299-W15-39	N	µg/L	3	0				
299-W15-40	N	µg/L	5	3	0.35	0.50	0.45	0.08
299-W15-41	N	µg/L	5	1	25.00	25.00	25.00	
299-W15-42	Y	µg/L	4	3	13.00	16.00	14.33	1.53
299-W15-42	N	µg/L	10	5	0.51	5.00	3.34	1.68
299-W15-43	N	µg/L	8	5	0.31	0.61	0.47	0.13
299-W15-7	N	µg/L	13	6	0.17	33.00	6.73	12.89
299-W18-1	Y	µg/L	1	1	2.00	2.00	2.00	
299-W18-1	N	µg/L	15	3	52.00	100.00	70.00	26.15
299-W18-23	N	µg/L	26	7	0.15	180.00	41.03	68.64
299-W18-27	N	µg/L	20	7	0.17	20.00	6.23	7.72
299-W6-10	N	µg/L	15	3	11.00	20.00	16.67	4.93
299-W6-2	N	µg/L	25	8	0.17	20.00	3.68	6.73
299-W6-7	N	µg/L	14	4	0.10	2.10	0.73	0.94
299-W7-12	N	µg/L	29	10	0.21	1.70	0.67	0.47
299-W7-4	N	µg/L	27	12	0.17	42.00	7.92	12.72
299-W7-7	N	µg/L	29	11	0.06	2.20	1.07	0.77
299-W7-8	Y	µg/L	1	0				
299-W7-8	N	µg/L	23	8	0.12	2.50	0.97	0.93
299-W8-1	N	µg/L	44	12	0.17	4.00	1.25	1.38
699-39-79	N		5	0				
699-39-79	N	µg/L	8	4	0.18	3.00	1.22	1.23
699-43-89	N	µg/L	5	0				
699-44-64	N	µg/L	6	1	2.00	2.00	2.00	
699-45-69A	N		1	0				
699-45-69A	N	µg/L	8	1	0.40	0.40	0.40	
699-47-60	N	µg/L	8	1	0.80	0.80	0.80	
699-48-71	N		1	0				
699-48-71	N	µg/L	12	5	0.30	2.00	1.03	0.89
699-48-77A	Y	µg/L	2	2	2.00	3.00	2.50	0.71
699-48-77A	N		1	0				
699-48-77A	N	µg/L	56	2	6.00	7.00	6.50	0.71

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
699-55-60A	N	µg/L	3	2	0.67	7.00	3.84	4.48
Fluoride								
299-W10-1	N	µg/L	21	21	310.00	2,400.00	816.05	779.93
299-W10-13	N	µg/L	27	27	240.00	900.00	367.19	160.18
299-W10-19	N	µg/L	35	35	230.00	740.00	421.57	159.15
299-W10-20	N	µg/L	28	28	257.00	900.00	409.64	190.09
299-W10-21	N	µg/L	29	29	274.00	800.00	440.17	175.45
299-W10-22	N	µg/L	27	27	290.00	710.00	491.63	91.48
299-W10-23	N	µg/L	20	20	3,040.00	4,300.00	3,614.00	351.35
299-W10-4	N	µg/L	28	28	1,900.00	5,250.00	3,100.00	920.94
299-W10-5	N	µg/L	8	8	210.00	600.00	336.25	117.95
299-W11-10	N	µg/L	10	10	290.00	690.00	434.50	140.65
299-W11-13	N	µg/L	3	3	280.00	320.00	303.33	20.82
299-W11-18	N	µg/L	14	14	910.00	2,000.00	1,322.86	393.45
299-W11-3	N	µg/L	4	4	370.00	750.00	555.00	197.74
299-W11-37	Y	µg/L	2	2	680.00	680.00	680.00	0.00
299-W11-37	N	µg/L	4	4	660.00	860.00	742.50	91.79
299-W11-6	N	µg/L	6	6	380.00	820.00	546.67	173.74
299-W11-7	N	µg/L	14	14	820.00	9,700.00	1,711.43	2,325.91
299-W12-1	N	µg/L	14	14	252.00	900.00	474.57	265.67
299-W14-14	N	µg/L	25	25	306.00	1,100.00	734.28	248.67
299-W14-16	N	µg/L	11	11	400.00	630.00	490.00	82.46
299-W15-1	N	µg/L	1	1	370.00	370.00	370.00	
299-W15-11	N	µg/L	4	4	360.00	700.00	467.50	156.50
299-W15-15	N	µg/L	25	25	291.00	650.00	403.68	90.14
299-W15-16	N	µg/L	24	24	440.00	1,100.00	600.29	170.12
299-W15-17	N	µg/L	22	22	239.00	700.00	362.59	119.07
299-W15-2	N	µg/L	7	7	270.00	550.00	350.00	100.33
299-W15-31A	N	µg/L	1	1	330.00	330.00	330.00	
299-W15-32	N	µg/L	7	7	320.00	780.00	514.29	186.74
299-W15-33	N	µg/L	1	1	430.00	430.00	430.00	
299-W15-34	N	µg/L	4	4	360.00	410.00	381.50	21.81
299-W15-35	N	µg/L	1	1	410.00	410.00	410.00	
299-W15-36	N	µg/L	4	4	400.00	500.00	450.00	40.82
299-W15-37	N	µg/L	4	4	450.00	520.00	492.50	34.03
299-W15-38	N	µg/L	1	1	450.00	450.00	450.00	
299-W15-39	N	µg/L	1	1	590.00	590.00	590.00	
299-W15-40	N	µg/L	18	18	235.00	790.00	338.00	134.12
299-W15-41	N	µg/L	15	15	480.00	620.00	521.33	36.81
299-W15-42	Y	µg/L	1	0				
299-W15-42	N	µg/L	7	7	290.00	590.00	462.86	119.12
299-W15-43	N	µg/L	7	7	260.00	450.00	372.86	63.96
299-W15-44	N	µg/L	9	9	350.00	2100.00	570.00	574.39
299-W15-7	N	µg/L	9	9	390.00	900.00	698.78	150.76
299-W18-1	N	µg/L	11	11	420.00	2400.00	918.64	540.09
299-W18-21	N	µg/L	24	24	288.00	700.00	400.54	118.68
299-W18-22	N	µg/L	24	24	253.00	600.00	347.50	88.92

Table C1-5. Minimum, Maximum, Average, and Standard Deviation Results. (31 sheets)

Location	Filtered	Unit	Count	Detects	Min	Max	Avg	StDev
299-W18-23	N	µg/L	24	24	288.00	1,000.00	420.92	149.11
299-W6-10	N	µg/L	27	27	254.00	1,100.00	500.00	251.66
299-W6-2	N	µg/L	33	32	240.00	900.00	455.25	166.64
299-W6-7	N	µg/L	14	14	370.00	800.00	564.29	165.00
299-W7-11	N	µg/L	26	26	280.00	800.00	373.46	126.82
299-W7-4	N	µg/L	27	27	260.00	630.00	372.93	108.10
299-W7-7	N	µg/L	29	29	300.00	700.00	407.28	89.81
299-W7-8	Y	µg/L	1	1	368.00	368.00	368.00	
299-W7-8	N	µg/L	23	23	342.00	700.00	450.09	106.34
299-W8-1	N	µg/L	44	44	200.00	700.00	291.77	103.31
699-39-79	N	µg/L	9	9	400.00	1,600.00	602.78	386.29
699-43-89	N	µg/L	5	5	94.00	470.00	236.80	141.74
699-44-64	N	µg/L	13	13	290.00	800.00	451.77	159.66
699-45-69A	N	µg/L	10	10	340.00	700.00	479.00	112.59
699-47-60	N	µg/L	15	13	470.00	900.00	633.38	121.14
699-48-71	N	µg/L	18	18	258.00	800.00	450.44	147.29
699-48-77A	Y	µg/L	2	2	290.00	300.00	295.00	7.07
699-48-77A	N	µg/L	54	54	160.00	700.00	342.06	113.38
699-55-60A	N	µg/L	7	7	497.00	1,300.00	798.14	276.85

C1.5 EVALUATION OF ANALYTICAL RESULTS FOR THE 200-ZP-1 GROUNDWATER MONITORING WELL NETWORK

The analytes listed below provide a summary of the data tables presented in Section C1.4.

- **Carbon tetrachloride:** The average concentration of carbon tetrachloride exceeded the limit in 51 of 58 wells sampled. Fifty-three of 58 wells sampled had a maximum result above the action limit.
- **Chloroform:** The average concentration of chloroform exceeded the limit in 31 of 58 wells with results. Forty of 58 wells had a maximum result above the action limit.
- **TCE:** The average concentration of TCE exceeded the limit in 28 of 58 wells with results. Thirty-seven of 58 wells had a maximum result above the action limit.
- **Chromium:** The average concentration of chromium exceeded the limit in 13 of 53 wells with results. Seventeen of 53 wells had a maximum result above the action limit.
- **Arsenic:** The average concentration of arsenic exceeded the limit in none of 40 wells with results. One of the 40 wells had a maximum result above the action limit.
- **Cadmium:** The average concentration of cadmium exceeded the limit in three of 53 wells with results. Five of the 53 wells had a maximum result above the action limit.
- **Strontium-90:** The average concentration of strontium-90 exceeded the limit in none of the 26 wells with results. None of 26 the wells had a maximum result above the action limit.

- **Iodine-129:** The average concentration of iodine-129 exceeded the limit in 5 of the 52 wells with results. Six of the 52 wells had a maximum result above the action limit.
- **Technetium-99:** The average concentration of technetium-99 exceeded the limit in one of the 54 wells with results. One of the 54 wells had a maximum result above the action limit.
- **Uranium:** The average concentration of uranium exceeded the limit in 2 of the 37 wells with results. Three of the 37 wells had a maximum result above the action limit.
- **Tritium:** The average concentration of tritium exceeded the limit in 7 of the 57 wells with results. Thirteen of the 57 wells had a maximum result above the action limit.
- **Nitrate:** The average concentration of nitrate exceeded the limit in 57 of the 59 wells with results. Fifty-eight of the 59 wells had a maximum result above the action limit. (Note: The data presented in Table C1-5 are reported as nitrate; the regulatory limit as nitrate is 12,400 μg/L.)
- **Antimony:** The average concentration of antimony exceeded the limit in 18 of the 54 wells with results. Eighteen of the 54 wells had a maximum result above the action limit.
- **Iron:** The average concentration of iron exceeded the limit in 25 of the 54 wells with results. Thirty-one of the 54 wells had a maximum result above the action limit.
- **Manganese:** The average concentration of manganese exceeded the limit in 10 of the 53 wells with results. Thirteen of the 53 wells had a maximum result above the action limit.
- **1,2-dichloroethane:** The average concentration of 1,2-dichloroethane exceeded the limit in 17 of the 59 wells with results. Eighteen of the 59 wells had a maximum result above the action limit.
- **Benzene:** The average concentration of benzene exceeded the limit in 21 of the 61 wells with results. Twenty-two of the 61 wells had a maximum result above the action limit.
- **Tetrachloroethylene:** The average concentration of tetrachloroethylene exceeded the limit in 15 of the 59 wells with results. Nineteen of the 59 wells had a maximum result above the action limit.
- **Methylene chloride:** The average concentration of methylene chloride exceeded the limit in 32 of the 58 wells with results. Thirty-five of the 58 wells had a maximum result above the action limit.
- **Fluoride:** The average concentration of fluoride exceeded the limit in none of the 60 wells with results. Three of the 60 wells had a maximum result above the action limit.

The COCs listed above are the key analytes for further routine evaluation in the groundwater and are listed in Table A3-1 in Appendix A.

C2.0 REFERENCES

40 CFR 141, "National Primary Drinking Water Regulations," *Code of Federal Regulations*, as amended.

Atomic Energy Act of 1954, 42 U.S.C. 2011, et seq.

BHI, 2001, *Calculation of Total Uranium Activity Corresponding to a Maximum Contaminant Level for Uranium of 30 Micrograms per Liter in Groundwater*, Calculation 0100X-CA-V0038, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, as amended, U.S. Department of Energy, Washington, D.C.

DOE-RL, 1992, *Hanford Site Groundwater Background*, DOE/RL-92-23, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 1996, *Limited Field Investigation for the 200-UP-1 Operable Unit*, DOE/RL-96-33, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL, 2002, *Remedial Design Report/Remedial Action Work Plan for the 100 Area*, DOE/RL-96-17, Rev. 4, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, 2001, *Cleanup Levels and Risk Calculations Under the Model Toxics Control Act Cleanup Regulation (CLARC), Version 3.1*, Publication No. 94-145, Washington State Department of Ecology, Toxics Cleanup Program, Olympia, Washington.

FH, 2003a, *Data Quality Objectives Summary Report for Establishing a RCRA/CERCLA/AEA Integrated 200 West and 200 East Groundwater Monitoring Network*, CP-15329, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

FH, 2003b, *Data Quality Objectives Summary Report Supporting the 200-ZP-1 Operable Unit Remedial Investigation/Feasibility Study Process*, CP-16151, Rev. 0, Fluor Hanford, Inc., Richland, Washington.

NBS, 1963, *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air or Water for Occupational Exposure*, Handbook 69, U.S. Department of Commerce, Washington, D.C.

Resource Conservation and Recovery Act of 1976, 42 U.S.C. 6901, et seq.

WAC 173-340, "Model Toxics Control Act – Cleanup," *Washington Administrative Code*, as amended.

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